Pain catastrophizing, mental health comorbidity, and problematic recovery outcomes following whiplash injury

Catherine Paré

Department of Psychology

McGill University, Montreal

September 2023

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy

Table of Contents

Abstract

Whiplash injuries are the most common form of injury following a motor vehicle collision. The risk of developing chronic pain following whiplash injury remains high, with as many as 50% of individuals continuing to report symptoms one year following injury. Over the past two decades, research has accumulated showing that psychosocial factors play a significant role in the experience of pain and disability associated with whiplash injury. In particular, pain catastrophizing has emerged as one of the most robust psychological predictors of problematic recovery following whiplash injury. However, research has yet to elucidate the pathways through which pain catastrophizing impacts recovery outcomes. The program of research described in this thesis was designed to test to hypothesis that pain catastrophizing has a negative impact on recovery outcomes by increasing the risk of experiencing debilitating mental health symptoms related to depression and post-traumatic stress disorder (PTSD).

The purpose of Study 1 was to identify the clinical cut-score on the Pain Catastrophizing Scale (PCS) indicative of heightened risk for experiencing comorbid depression and PTSD. A second objective of Study 1 was to determine whether the presence of clinically significant symptoms of depression and PTSD might act as vehicles through which pain catastrophizing might impact on occupational disability. Results revealed that a PCS score of 22 best distinguished between participants with and without mental health comorbidity. In addition, findings showed that mental health comorbidity was a pathway through which pain catastrophizing impacted occupational disability. These findings suggest that the PCS could be used to alert clinicians to the possible presence of clinically significant mental health conditions, and that mental health symptoms, in conjunction with pain catastrophizing, might be important targets of intervention following whiplash injury.

In Study 2, we investigated the direction of influence of pain catastrophizing on pain severity and symptoms of mental health problems in individuals with whiplash injuries. Although pain catastrophizing has been shown to be a prognostic indicator for pain severity and the co-occurrence of mental health symptoms of depression and/or PTSD following whiplash injury, the pattern of existing findings is limited in its implications for the possible 'causal' or 'antecedent' role of pain catastrophizing. A cross-lagged panel analysis was used to explore the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and PTSD symptoms at all three timepoints. Model fit was acceptable and revealed that pain catastrophizing at Time 1 (baseline) and Time 2 (4 weeks later) predicted all other variables at the following timepoints (4 and 7 weeks, respectively). These findings support the view that pain catastrophizing might play a transdiagnostic role in the onset and maintenance of health and mental health conditions.

Taken together, the results of the studies in the current thesis improve our understanding of the relations between pain catastrophizing, mental health difficulties, and pain-related recovery outcomes. The findings provide evidence for the important role of pain catastrophizing in clinical outcomes following whiplash injury and emphasize the importance of developing treatment techniques that target pain catastrophizing in intervention programs for whiplash injury. Greater attention to the detection and treatment of mental health conditions, through the assessment and targeting of pain catastrophizing, might contribute to more positive recovery outcomes following whiplash injury.

Résumé

Les entorses cervicales sont les blessures les plus communes à la suite d'un accident de voiture. Le risque de développer une douleur chronique à la suite d'une entorse cervical demeure élevé : jusqu'à 50% des individus blessés rapportent des symptômes un an après leur blessure. Au cours des deux dernières décennies, la recherche démontrant le rôle significatif de la pensée catastrophique lors de l'expérience de douleur et d'invalidité associé aux entorses cervicales s'est accrue. En revanche, les voies par lesquelles la pensée catastrophique face à la douleur impacte les résultats du rétablissement demeurent incertaines. Cette thèse a été conçu pour tester l'hypothèse que la pensée catastrophique face à la douleur augmente le risque de développer des symptômes incapacitants de santé mentale relié à la dépression ou à un trouble de stress post-traumatique (PTSD), lesquels ont un impact néfaste sur les résultats du rétablissement.

Le but de l'étude 1 était d'identifier un point de coupure sur l'Échelle de pensée catastrophique face à la douleur (PCS) indiquant un risque élevé de subir une dépression ou PTSD comorbide. Un deuxième objectif était de déterminer si la présence de symptômes cliniquement significatifs de dépression et de PTSD pourrait être une façon par laquelle la pensée catastrophique face à la douleur pourrait avoir un impact sur l'invalidité professionnelle. Les résultats ont démontré qu'un point de coupure de 22 sur le PCS permettait à identifier les participants avec un trouble de santé mentale comorbide. De plus, les résultats suggèrent que la pensée catastrophique face à la douleur impacte l'invalidité professionnelle à travers la présence de trouble de santé mentale comorbide. Ces résultats suggèrent que le PCS pourrait alerter les cliniciens à la présence potentielle de symptômes cliniquement significatifs de troubles de santé mentale. De plus, les symptômes de troubles de santé mentale à la suite d'une entorse cervicale pourraient être une cible d'intervention importante conjointement avec la pensée catastrophique.

Lors de l'étude 2, nous avons investigué l'influence directionnelle de la pensé catastrophique face à la douleur sur les symptômes de trouble de santé mentale et sur l'intensité de la douleur chez les individus avec une entorse cervicale. Alors que la pensée catastrophique face à la douleur s'est révélée être un indicateur prognostique pour l'intensité de la douleur et cooccurrence des symptômes de trouble de santé mentale comme la dépression et le PTSD à la suite d'une entorse cervicale, le modèle des résultats de la recherche déjà existant est limité dans sa capacité d'impliquer un rôle possiblement 'antécédant' de la pensée catastrophique face à la douleur. Une analyse de modèle autorégressif démontra que les niveaux antérieurs de pensée catastrophique face à la douleur pouvaient prédire les niveaux postérieurs de l'intensité de la douleur et des symptômes de dépression et de PTSD. Ces résultats appuient la perspective que la pensée catastrophique face à la douleur pourrait jouer un rôle transdiagnostique pour les conditions de santé et de santé mentale.

Vus dans l'ensemble, les résultats des études de la thèse actuelle améliorent notre compréhension de la relation entre la pensée catastrophique face à la douleur, les troubles de santé mentale, et les résultats du rétablissement reliés à la douleur. Les résultats fournissent des preuves du rôle important de la pensée catastrophique face à la douleur lors des résultats cliniques à la suite d'une entorse cervicale. De plus, les résultats soulignent l'importance du développement des techniques d'intervention ciblant la pensée catastrophique face à la douleur lors des programmes d'intervention pour les entorses cervicales. Évaluer et cibler la pensée catastrophique face à la douleur permettrait davantage la détection et le traitement des troubles de santé mentale, ainsi améliorant les résultats de rétablissement suite d'une entorse cervicale.

Acknowledgements

The thesis has been the product of many years of hard work that could not have been achieved alone. Of course, a big thank you to Mick, who supervised me over all these years and through the ups and downs of a pandemic! I always have and will continue to admire your clear, logical, and eloquent method of conducting research and, especially, writing. I have also greatly appreciated the support and opportunities that you've provided me.

A big thank you as well to other important figures who guided me through the PhD in the Psychology department. Thanks to Dr. David Zuroff and Dr. Mathieu Roy for being on my advisory committee. Your feedback and advice over the years has helped shape my thesis as it is today. A massive thank you to the administrative staff in the department, in particular Chantale Bousquet, Giovanna LoCascio, and Nina Pinzarrone, without whom I would have been totally lost on the long and winding road of the PhD!

I have received a considerable amount of informal mentorship over the years, and would like to thank each of these individuals: David Zuroff, Marc O. Martel, Whitney Scott, Junie Carriere, Ann Gamsa, Julien Lacaille, Allen Steverman, Billie Jo Bogden, Neil Andrews, and Sandra Woods. It might have just been one conversation or perhaps it was many, but your words have stuck with me and guided me throughout my graduate studies.

I'd also like to thank all of the "pain (research) people" who have crossed my path over the past 6 years, whether in Mick's lab, the Psychology department, at McGill, in the province of Québec, in Canada or internationally. Being in a small lab is tough, but meeting other people who are doing inspiring research work, connecting with friends with common interests, helping to bring pain research to the general public – these are all things that made my PhD a bit easier. I'd like to especially thank Arthur Woznowski-Vu for being my PhD sibling (now big brother!),

connecting me to the bigger world of pain research, and doing a cool research project together! I also want to recognize what an amazing organization the QNJPI is; the friends I made while being on the QNJPI BoD were and continue to be truly inspiring.

As a clinical psychology student, I would be remiss to not acknowledge the clinical cohort that I "grew up with": Iulia, Ally, Serena, Erika, and Amanda, I would not have survived the earlier years without you! I loved our way of supporting each other through our immense course load, initial experiences trying to be therapists, successes and challenges in our later clinical placements, and yearly birthday cards and presents! In particular, I want to thank Iulia for being such an honest, present, and empathic friend over the years.

Finally, I'd like to thank all my friends and family for quietly (but sometimes loudly!) cheering me on as I pursued *even more* school. Your encouragement and listening when I always complained about being stressed helped me through this major challenge and accomplishment! Special mentions go out to Kendra and Julia for being incredible friends. And finally, my partner-in-crime, Lucas: your constant support and love (whether by offering me tea, complaining about doing PhDs, or watching anime together) has been invaluable over the past 5 years. Thank you all so much for making this possible.

Contribution of Original Knowledge

Although previous findings suggest that (1) both pain catastrophizing and mental health conditions impact on recovery outcomes following whiplash injury, and (2) there are significant associations between pain catastrophizing and mental health conditions in individuals with whiplash injury, the nature of the relationship between pain catastrophizing and mental health following whiplash injury and how this impacts recovery remained unclear. The current thesis is composed of two original manuscripts that were written to address these gaps in the literature. Study 1 (Chapter 2) was accepted as a peer-reviewed publication in *Clinical Journal of Pain*. Study 2 (Chapter 3) has been submitted to a peer-reviewed journal, *Clinical Journal of Pain*, and is awaiting a response following an initial revision of the manuscript.

The work presented in the current thesis aimed to address these knowledge gaps in several ways. Study 1 focused on the clinical implications of the associations between pain catastrophizing and mental health conditions following whiplash injury. We specifically explored the relationship between the presence of clinically significant symptoms of mental health conditions (i.e., depression and PTSD) and pain catastrophizing. Study 1 was the first to determine a clinical cut-score on the PCS which indicates heightened risk of experiencing clinically significant symptoms of depression and/or PTSD. As such, Study 1 advances existing knowledge in the whiplash rehabilitation literature by providing clinicians with a tool (i.e., a cut-score of 22 on the PCS) signaling a heightened risk of experiencing a mental health condition, thereby providing information on when to refer patients to a mental health specialist.

Study 1 also aimed to advance our understanding of the clinical implications of the relationship between pain catastrophizing and mental health symptoms from a mechanistic perspective. Findings from Study 1 revealed that pain catastrophizing impacted occupational

disability one year following treatment through the presence of mental health comorbidity (i.e., the presence of clinically significant symptoms of depression and/or PTSD). Study 1 advances existing knowledge in the whiplash rehabilitation literature by demonstrating that pain catastrophizing contributes to challenges in returning to work following a whiplash injury through clinically significant symptoms of depression and PTSD.

Study 2 was conceived to directly address the temporal nature of the relations between symptoms of mental health conditions (i.e., depression and PTSD), pain catastrophizing, and pain severity. Study 2 was the first empirical study to demonstrate the antecedent role of pain catastrophizing in predicting mental health symptoms (i.e., depression and PTSD) and pain severity during treatment for whiplash injury. Study 2 contributes original knowledge to the literature on psychosocial risk factors by providing preliminary evidence for the potential transdiagnostic role of pain catastrophizing in negatively impacting depressive symptoms, PTSD symptoms, and pain severity during treatment following whiplash injury.

Contribution of Authors

This thesis consists of two multi-authored manuscripts. The author of this thesis, Ms. Catherine Paré, was the primary author on each of these manuscripts. Study 1 was co-authored with Dr. Pascal Thibault, Dr. Pierre Côté, honours thesis students Ms. Stephania Donayre Pimentel and Ms. Shiyang Shen, Dr. Esther Yakobov, and Dr. Michael Sullivan, Ms. Paré's PhD supervisor. Study 2 was co-authored with Dr. Keiko Yamada and Dr. Michael Sullivan. As lead author of both studies, Ms. Paré conceptualized the study design, planned and performed all data analyses, wrote the manuscripts, and responded to reviewers following submission of the manuscripts. In addition, Dr. Michael Sullivan provided guidance and support for both studies with respect to study design, data analysis, manuscript preparation, and revisions. For Study 1, Dr. Pascal Thibault assisted with data collection and manuscript revisions. Dr. Pierre Côté and Dr. Esther Yakobov assisted with manuscript preparation and revisions. Ms. Stephania Donayre Pimentel and Ms. Shiyang Shen assisted in conducting preliminary research for conceptualizing the study design as well as manuscript preparation. For Study 2, Dr. Keiko Yamada assisted with planning and performing data analyses as well as manuscript revisions.

List of Abbreviations

ACT: Acceptance and Commitment Therapy

AUC: Area Under the Curve

AUD: Australian Dollars

β: Standardized regression coefficient

BDI-II: Beck Depression Inventory – II

CAD: Canadian Dollars

CBT: Cognitive Behavioural Therapy

CFI: Comparative Fit Index

CI: Confidence interval

CIHR: Canadian Institute of Health Research

CRC: Canada Research Chair

CSQ: Coping Strategies Questionnaire

d: Cohen's d effect size

FIML: Full Information Maximum Likelihood

IES-R: Impact of Event Scale – Revised

IRSST: Institut de recherche Robert-Sauvé en santé et en sécurité du travail

MDD: Major Depressive Disorder

MPQ: McGill Pain Questionnaire

MPQ-PRI: Pain Rating Index of the McGill Pain Questionnaire

n: Sample size

n.s.: Non-significant

NRS: Numerical rating scale

NSAIDS: Non-steroidal anti-inflammatory drug

OR: Odds ratio

OTC: Over the counter

p: p-value

PCS: Pain Catastrophizing Scale

PTSD: Post-traumatic stress disorder

PTSS: Post-traumatic stress symptoms

r: Pearson correlation coefficient

R^2: Coefficient of determination

RCT: Randomized controlled trial

ROC: Receiver Operating Curve

RMSEA: Root Mean Square Error of Approximation

RTW: Return to work

SAAQ: Société de l'assurance automobile du Québec

SD: Standard deviation

SE: Standard error

SPSS: Statistical Package for the Social Sciences

SRMR: Standardized Root Mean Square Residual

t: t-statistic

TLI: Tucker-Lewis Index

T1: baseline/time of admission

T2: mid-treatment (4 weeks after T1)

T3: post-treatment (7 weeks after T1)

WAD: Whiplash-Associated Disorder

χ^2: Chi-square

Y/N: ‘yes or no’ (dichotomous variable)

Chapter 1: General Introduction

Whiplash injuries, also referred to as whiplash-associated disorders (WAD), are a common type of injury sustained in motor vehicle collisions (Joslin et al., 2004). Whiplash injuries are musculoskeletal injuries characterized by trauma to the soft tissues of the cervical spine due to the sudden acceleration and deceleration, and subsequent flexion and extension, of the head and neck (Spitzer et al., 1995). Nearly 2 million emergency department visits are attributed to whiplash injuries arising from motor vehicle collisions every year in North America (Niska et al., 2010). In North America, the yearly economic burden of whiplash injury is estimated to be in excess of 250 billion dollars due to health care costs, lost productivity, wage replacement, and litigation (Blincoe et al., 2002; Foreman & Croft, 2002).

Whiplash injury is associated with the highest costs of all injuries incurred in motor vehicle collisions (Cassidy et al., 2000; Pink et al., 2016; Quinlan et al., 2004). A study of road trauma patients with neck pain found that the mean cost per patient, including acute and post-acute (i.e., after the initial post-accident hospital visit) care, was 10 153 $AUD (10 506 $CAD[1]; SD = 10 791 $AUD) (Ackland et al., 2012). Over half of the total post-acute costs incurred by the sample were due to the loss of earnings experienced by study participants following their injury (161 200 $AUD; 166 809 $CAD[2]). The prevalence of pain-related disability associated with musculoskeletal disorders has been increasing steadily despite numerous policy, prevention, and intervention initiatives launched to date (Overaas et al., 2017).

In 1995, the Quebec Task Force developed the Quebec classification of Whiplash-Associated Disorders to distinguish between different levels of severity of whiplash injury (Spitzer et al., 1995). These levels include WAD Grade 0 (no neck complaints or physical signs

[1] Converted from the average AUD to CAD exchange rate in the publication year of the study (2012).
[2] See footnote 1.

of injury), WAD Grade I (neck complaints such as pain, stiffness, or tenderness), WAD Grade II (neck complaint with musculoskeletal signs such as limited range of motion), WAD Grade III (neck complaint with neurological signs such as headaches, dizziness, or tinnitus), and WAD Grade IV (neck complaint with fracture or dislocation). Given that WAD Grade 0 implies no pain or disability, and that the mechanisms of injury for WAD Grade IV involve nerve damage, most relevant in the discussion of recovery following a musculoskeletal injury are WAD Grades I-III.

The risk of developing chronic pain following whiplash injury remains high. As many as 50% of individuals who have sustained whiplash injuries will remain symptomatic one year following injury (Carroll et al., 2008; Sterling, 2016). Once symptoms of pain and disability become chronic, available methods of managing pain, whether pharmacological, physical, or psychological, have only modest impact on suffering and function (Cote et al., 2016). Individuals who remain work-disabled at 3-months post-injury have a high likelihood of permanent disability (da Silva et al., 2017).

In early research, an emphasis was placed on exploring the role of biomedical factors, such as mechanism of injury, tissue lesions or tissue pathology, as predictors of problematic recovery following whiplash injury (Carstensen, 2012). However, research over the past 30 years has increasingly supported the view that traditional biomedical models cannot fully account for problematic recovery following whiplash injury. Biopsychosocial models of pain and pain-related disability have now replaced traditional medical models as the dominant conceptual frameworks guiding research and practice on whiplash injury (Ferrari & Schrader, 2001; Turk et al., 2018; Walton & Elliott, 2017). These models propose that a complete understanding of pain-

related outcomes following a whiplash injury will require consideration of the interplay among biological, psychological, and social factors.

Pain catastrophizing has emerged as one of the most robust psychological predictors of problematic recovery following whiplash injury (Sarrami et al., 2017; Sullivan et al., 2011). Pain catastrophizing has been defined as an "exaggerated negative mental set brought to bear during actual or anticipated threat, comprised of elements of helplessness, rumination, and magnification" (Sullivan, Thorn, et al., 2001, p. 53). However, the pathways by which pain catastrophizing impacts recovery outcomes following whiplash injury remain unclear. Several cross-sectional and prospective studies have revealed that pain catastrophizing contributes to the onset and maintenance of mental health problems. Specifically, research has shown that high levels of pain catastrophizing predict more severe and prolonged symptoms of depression and post-traumatic stress symptoms (PTSS) following whiplash injury (Andersen et al., 2016; Carstensen, 2012; Laporte et al., 2016; Nieto et al., 2011; Sarrami et al., 2017). As such, it is possible that the mental health problems brought about and sustained by pain catastrophizing following whiplash injury might negatively impact recovery outcomes.

The current thesis aims to extend previous research by examining the predictive role of pain catastrophizing on the relationship between mental health difficulties and problematic recovery outcomes following whiplash injury. The Introduction will begin with a discussion of the definition of pain catastrophizing in the context of pain and mental health research. Subsequently, an overview of current conceptualizations of pain catastrophizing will be provided. The final section of the Introduction will present research linking pain catastrophizing to problematic recovery outcomes, followed by a description of knowledge gaps in the literature and objectives of the thesis.

Defining pain catastrophizing

Albert Ellis first described catastrophic thinking in the 1960s as a general factor in psychopathology characterized by the magnification of both perceived threats and their potential consequences (Ellis, 1962). In the 1970s, Aaron Beck applied Ellis' definition of catastrophic thinking as an explanatory construct for the development of depression and anxiety disorders. Beck's model suggested that catastrophic thinking was a form of faulty information processing in which an individual magnifies the significance of a negative event (Beck et al., 1979).

Catastrophizing was first introduced into pain-related research in the late 1970s. Similar to the definitions of Beck and Ellis in mental health contexts, catastrophizing was initially defined as a maladaptive cognitive coping strategy characterized by the exaggeration of the perceived threat of an experience (i.e., of pain) (Chaves & Brown, 1987). These researchers conducted a study of 75 participants undergoing dental procedures and found that over a third of participants engaged in catastrophizing (Chaves & Brown, 1978, 1987). The authors suggested that pain catastrophizing was a cognitive coping strategy used for managing pain and stress (Chaves & Brown, 1987). Spanos and colleagues (1979) expanded upon this line of research by exploring the cognitive strategies used by healthy participants during the cold pressor task (Spanos et al., 1979). The authors hypothesized that catastrophizing was a cognitive factor that might influence how much pain participants reported. The study found that participants who reported higher levels of pain catastrophizing did not experience a reduction in self-reported pain during or following the cold pressor task, regardless of the number of cognitive strategies they reported using during the task. The authors proposed that individuals who reported a higher frequency of catastrophic thoughts demonstrated increased attention to pain-related stimuli, or 'rumination' about pain (Spanos et al., 1979). In 1983, Rosenstiel and Keefe developed the

Coping Strategies Questionnaire (CSQ) to help identify the coping strategies used by individuals experiencing chronic pain (Rosenstiel & Keefe, 1983; Rosenstiel & Roth, 1981). The CSQ comprises several subscales, including a Catastrophizing subscale, which was found to strongly load onto the 'helplessness' factor of the CSQ (Rosenstiel & Keefe, 1983).

Findings from the development of the CSQ, which highlighted the relations between catastrophizing and helplessness, contrasted with earlier definitions of pain catastrophizing by Beck, Ellis, and Chaves and Brown, which focused primarily on a 'magnification' conceptualization of catastrophizing, as well as research and conceptualizations by Spanos and colleagues, which focused primarily on the 'rumination' aspect of catastrophizing. The Pain Catastrophizing Scale (PCS) was developed by Sullivan and colleagues (Sullivan et al., 1995) to reflect the multiple dimensions of pain catastrophizing illustrated in empirical findings. Factor analyses of the PCS supported a three-dimensional structure for the PCS, with subscales for magnification, rumination, and helplessness (Sullivan et al., 1995). The PCS is the most widely-used scale for assessing pain catastrophizing and has repeatedly been found to be valid and reliable (Wheeler et al., 2019).

Conceptual models of pain catastrophizing

A number of different conceptual frameworks have been put forward to account for the robust relation between pain catastrophizing and adverse pain outcomes. The concept of schema activation was the general basis for Beck's cognitive model for depression and anxiety disorders (Beck et al., 1979). The schema activation model proposes that a schema is activated in the context of a stressor or a threatening event or situation. According to Beck, catastrophizing was one of many cognitive distortions that could manifest following the activation of schemas related to psychopathology such as depression (Beck et al., 1979). Catastrophizing was considered a

form of faulty information processing in which the significance of an event was magnified, thereby contributing to depressive thought processes and leading to the development and maintenance of depressive symptoms (Beck et al., 1979). In the context of pain, the schema activation model suggests that pain might act as the threatening event or situation which activates certain schemas, subsequently leading to the manifestation of cognitive distortions such as catastrophizing (Sullivan et al., 1997; Sullivan et al., 1998; Sullivan, Thorn, et al., 2001). However, this model provides little information on the purpose of pain catastrophizing, nor the mechanisms through which pain catastrophizing impacts pain-related outcomes.

A conceptual model of pain catastrophizing related to the schema activation model is the transactional model of stress (Lazarus & Folkman, 1984). This model seeks to distinguish between appraisals, beliefs, and coping in the context of experiencing and reacting to stressors (Lazarus & Folkman, 1984; Sullivan, Thorn, et al., 2001). The model proposes different levels of appraisal: a primary appraisal refers to the judgement of how stressful a particular stimulus might be, whereas a secondary appraisal is a judgement about one's ability to cope with a stressor, in part related to the effectiveness of their anticipated coping style (Lazarus & Folkman, 1984). Through the lens of the transactional model of stress, researchers have proposed that pain catastrophizing is cognitive approach for coping with internal and external stressors and can act as both a primary and a secondary appraisal (Keefe et al., 1999; Sullivan, Thorn, et al., 2001). As such, it has been suggested that Lazarus and Folkman's transactional model of stress might provide an explanatory account for the different components of catastrophic thinking. The rumination and magnification aspects of pain catastrophizing could be construed as primary appraisals of a pain situation, impacting how stressful the pain experience is expected to be. On the other hand, the helplessness component of pain catastrophizing could be construed as a

secondary appraisal due to its influence on the perceived ability to cope with pain (Sullivan, 2012; Sullivan et al., 1995).

Another model developed to understand pain catastrophizing is the communal coping model, which proposes that pain catastrophizing acts as a method of eliciting support or empathy from others (Sullivan, 2012; Sullivan, Thorn, et al., 2001). Individuals with elevated levels of catastrophizing might preferentially manage distress in an interpersonal context through the display of pain behaviours (Sullivan, 2012). However, the interpersonal responses to an increased display in pain behaviours (e.g., increased short-term support, reduced expectations) could reinforce pain and illness-related behaviors over time (Craner et al., 2016). Gauthier and colleagues (2011) explored how spousal levels of pain catastrophizing impacted the pain behaviours of individuals living with chronic pain during a lifting task. Study results revealed that the greatest amount of pain behaviour was demonstrated by participants with high levels of pain catastrophizing living with spouses with low levels of pain catastrophizing. These findings were interpreted as support for the communal coping model by suggesting that participants with chronic pain and elevated levels of catastrophizing might demonstrate increased pain behaviours to compensate for their partners' underestimation of pain intensity (Gauthier et al., 2011). More recently, a daily diary study of the relationship between pain catastrophizing, partner support, and pain intensity in individuals with end-stage knee osteoarthritis found that, on days when participants reported receiving less partner support, those with high levels of pain catastrophizing reported greater pain intensity than participants with low levels of pain catastrophizing (Carriere et al., 2020).

More recently, a conceptualization of catastrophizing as repetitive negative thinking has been proposed (Flink et al., 2013). Repetitive negative thinking is a core component of emotion

dysregulation in many models of psychopathology (Linton, 2013). This model proposes that pain catastrophizing is an abstract cognition that is intrusive and difficult to disengage from (Flink et al., 2013). The primary function of pain catastrophizing is to help with emotion regulation, both by promoting problem-solving as well as by allowing for the avoidance of emotional and somatic processing (Flink et al., 2013). As such, pain catastrophizing could be considered a form of experiential avoidance (Linton et al., 2016). ACT-based interventions for pain support the repetitive negative thinking model by demonstrating their effectiveness for reducing levels of pain catastrophizing (Luciano et al., 2014). In addition, there exists empirical evidence to support the significant relations between worry and pain catastrophizing (Day et al., 2015). A recent qualitative study on the metacognition of individuals living with chronic low back pain and elevated levels of pain catastrophizing found that many participants reported that rumination was an important problem-solving strategy (Schutze et al., 2017). The repetitive negative thinking model suggests that cognitions, emotions, and behaviours related to pain catastrophizing cannot be separated, thereby proposing a more holistic understanding of this process compared to previously proposed models.

In addition to these pain-specific theories, some pain researchers have identified the relevance of generalizing the conceptualization of catastrophizing beyond the domain of pain. The role of pain catastrophizing as a maladaptive cognition has been included in theoretical models explaining the high rates of comorbidity between pain and post-traumatic stress disorder (PTSD), such as the mutual maintenance and shared vulnerability models (Asmundson et al., 2002; Ehlers & Clark, 2000; Sharp & Harvey, 2001). The mutual maintenance model suggests that PTSD and pain are developed and mutually maintained by a number of cognitive, emotional, and behavioural factors, including pain catastrophizing. Indeed, it is possible that someone who

interprets their pain in a catastrophic manner might tend to experience symptoms of PTSD through a catastrophic lens as well. Similarly, the notion that pain catastrophizing plays an important role in both pain and depressive conditions was introduced over a decade ago (Linton & Bergbom, 2011). Today, some clinicians have pointed to catastrophic thinking as having a causal role in many different mental health conditions (Gellatly & Beck, 2016). This transdiagnostic conceptualization of catastrophizing proposes that catastrophizing might act a maladaptive cognition across different psychopathologies. Gellatly and Beck's (2016) transdiagnostic model further suggests that catastrophizing might act as a common cognitive vulnerability process across a range of health and mental health conditions, with specific cognitive content related to catastrophizing varying across individual conditions (e.g., phobia, depression, pain).

Consequences of pain catastrophizing

There is a vast body of literature on the role of pain catastrophizing as a determinant of problematic recovery outcomes following a whiplash injury. Given that research on the impact of pain catastrophizing following musculoskeletal injury has covered a wide variety of outcomes, this thesis will focus on discussing the following outcomes: pain severity, mental health difficulties (specifically, depression and PTSD), and occupational disability.

Pain severity

The findings of cross-sectional and prospective studies have been consistent in showing that pain catastrophizing contributes to more severe pain (Birch et al., 2019; Edwards et al., 2016; Gilliam et al., 2019; Sullivan, Thorn, et al., 2001). Reviews of the literature suggest that pain catastrophizing accounts for 7% to 31% of the variance in measures of pain severity (Sullivan, Thorn, et al., 2001). Pain catastrophizing has been shown to be a significant

determinant of pain severity even when controlling for other pain-related psychological variables such as depression, fear of movement, anxiety, and symptoms of PTSD (Andersen et al., 2016; Ruscheweyh et al., 2017; Sullivan et al., 2008). The relation between pain catastrophizing and pain severity has been shown in numerous pain populations, including whiplash injury (Baltov et al., 2008), low back pain (Picavet et al., 2002), arthritis (Edwards, Bingham, et al., 2006), fibromyalgia (Lazaridou et al., 2020), neuropathic pain (Mankovsky et al., 2012), and headache (Buenaver et al., 2008). Several studies have also shown the impact of pain catastrophizing on pain severity in healthy participants following experimental pain manipulations (Campbell et al., 2010; Seminowicz & Davis, 2006; Trost et al., 2015) as well as experimental manipulations of pain catastrophizing (Severeijns et al., 2005).

The results of prospective studies suggest that high levels of pain catastrophizing might represent a risk factor for the development of chronic pain (Casey et al., 2011; Linton et al., 2011). Bostik et al. (2013) examined the role of pain catastrophizing as a predictor of long-term pain in a sample of individuals being treated for acute whiplash. Scores on a measure of pain catastrophizing predicted unique variance in pain intensity at 3- and 6-month follow-up, even when controlling for baseline measures of pain intensity and disability (Bostick et al., 2013). Casey et al. (2015) reported that high post-injury scores on a measure of pain catastrophizing were associated with the persistence of pain symptoms in individuals who had lodged a claim for whiplash injury (Casey et al., 2015). Gopinath et al. (2015) examined predictors of problematic recovery in a sample of individuals who sustained mild to moderate injuries in a motor vehicle crash. They reported that each unit increase on a baseline measure of pain catastrophizing was associated with a 0.5-unit increase (on a 0 – 10 scale) in pain severity at 12 months post-injury (Gopinath et al., 2015). Several other investigations have identified pain catastrophizing as a

prognostic indicator for poor recovery following whiplash injury (Carstensen, 2012; Laporte et al., 2016; Ritchie & Sterling, 2016; Sarrami et al., 2017).

Numerous investigations have revealed that pain catastrophizing is associated with several markers of pathological pain processing. One of the most consistent findings has been the association between pain catastrophizing and increased temporal summation of pain (Edwards, Smith, et al., 2006; Granot et al., 2006; Rhudy et al., 2011; Sullivan et al., 2010). Temporal summation reflects *pain facilitation processes* and is operationally defined as the increase in self-reported pain in response to repeated noxious stimulation. Temporal summation involves the central sensitization of dorsal horn neurons in response to the repeated or sustained activation of unmyelinated peripheral afferent C-fibres (Staud et al., 2007). Edwards et al. (2006) found that individuals with high levels of pain catastrophizing reported significantly greater increases in pain ratings than individuals with low levels of pain catastrophizing during the application of repeated painful heat stimulations (Edwards, Smith, et al., 2006). Similarly, other researchers have shown that pain catastrophizing is a significant predictor of increases in pain ratings across repeated noxious heat pulses, even when controlling for sex and pain-related fear (George et al., 2007). Pain catastrophizing has also been found to be a significant cross-sectional predictor of sensitivity to physical activity in participants with knee osteoarthritis (Wideman et al., 2014).

Numerous studies have also shown a relation between pain catastrophizing and conditioned pain modulation. Conditioned pain modulation reflects *pain inhibition processes* and has been operationally defined as the reduction in pain severity experienced in response to a noxious stimulus when a second noxious stimulus is applied to another part of the body (i.e., the degree to which pain inhibits pain) (Yarnitsky, 2010). A relation between pain catastrophizing and inefficient pain inhibition has been demonstrated in individuals with post-surgical pain

(Grosen et al., 2014), chronic pain (Christensen et al., 2020), and healthy individuals following experimental pain induction (Goodin et al., 2009; Weissman-Fogel et al., 2008).

Research has also revealed a relation between pain catastrophizing and multi-site pain. Some investigators have proposed that the distribution of pain symptoms might be a separate dimension of pain, beyond pain quality or severity (Coggon et al., 2013). Bortsov et al. (2013) reported a significant association between pain catastrophizing and multi-site pain in a sample of patients recruited from emergency departments following a motor vehicle collision (Bortsov et al., 2013). An experimental study conducted with healthy students similarly revealed that pain catastrophizing prospectively predicted the number of pain sites after pain was experimentally induced using a delayed-onset muscle soreness protocol (Niederstrasser et al., 2014).

Several investigations have also examined the neuroanatomical correlates of pain catastrophizing. Gracely and colleagues (2004) reported that neural activity increased as a function of catastrophizing levels in brain regions implicated in the anticipation of pain (medial frontal cortex, cerebellum), attention to pain (contralateral rostral anterior cingulate gyrus, bilateral dorsolateral prefrontal cortex), emotional aspects of pain (ipsilateral claustrum), and motor control (parietal cortex, lentiform nucleus) (Gracely et al., 2004). Similar findings were reported by Seminowicz and Davis (2006) in an experimental study of the relation between pain catastrophizing and brain activation. They found that pain catastrophizing was positively correlated with activation in brain areas implicated in pain facilitation processes (rostral anterior cingulate cortex, bilateral insula, dorsolateral prefrontal cortex, thalamus, putamen, and premotor cortex), and negatively correlated with activity in brain regions implicated in pain inhibition (bilateral dorsolateral prefrontal cortex, right temporal lobe, posterior parietal lobe, amygdala, and lateral primary somatosensory cortex) (Seminowicz & Davis, 2006). Indeed, there is even

research evidence to suggest that activation in brain regions related to the anticipation of pain mediates the relationship between pain catastrophizing and pain sensitivity (Loggia et al., 2015).

Depression

Research on catastrophic thinking is vast but has largely taken place in the domain of pain, despite the origins of catastrophizing in mental health. There is little research exploring the impact of catastrophic thinking in populations impacted by a diagnosed depressive condition, but the existing evidence is promising. One study conducted with participants diagnosed with Major Depressive Disorder (MDD) found prospective evidence for the role of pain catastrophizing in predicting many physical aspects of quality of life (Chung et al., 2012). Additionally, in a sample of 80 work-disabled individuals with MDD, reductions in catastrophizing significantly predicted occupational re-engagement following a psychosocial intervention (Adams et al., 2017).

In the context of pain, many researchers have highlighted the importance of examining the relations between catastrophizing and depression (Linton et al., 2011; Quartana et al., 2009). The results of previous investigations have shown moderate to high correlations between pain catastrophizing and depression (Burns et al., 2003; Geisser et al., 1994; Gilliam et al., 2017; Hulsebusch et al., 2016). Some of the earliest findings of significant correlations between catastrophizing and depression (Rosenstiel & Keefe, 1983) resulted in debate regarding the conceptual similarities between measures of depression and measures of catastrophizing (Haaga, 1992; Sullivan & D'Eon, 1990). Ultimately, research led to an early consensus that catastrophizing was a construct related, but not identical, to depression (Geisser et al., 1994; Keefe et al., 2000; Sullivan et al., 1995; Sullivan, Rodgers, et al., 2001; Sullivan et al., 1998).

Since this conclusion was tentatively drawn three decades ago, research has continued to elaborate on the relationship between pain catastrophizing and depression through cross-

sectional and prospective studies. High levels of pain catastrophizing are often found in conjunction with high levels of depression and are often associated with high pain severity and interference (Borsbo et al., 2009; Sullivan, Simmonds, et al., 2006). Pain catastrophizing has also consistently been shown to predict depressive symptoms in different musculoskeletal conditions, such as rheumatic disease (Shim et al., 2017), whiplash injuries (Nieto et al., 2011), and work-related musculoskeletal injuries (Lee et al., 2008). A recent population-based study found that, as the number of yearly assessments in which participants reported higher levels of pain catastrophizing increased, the likelihood that they were experiencing chronic depressive symptoms increased significantly (OR = 2.80 for one assessment; OR = 20.45 for all five assessments) (Glette et al., 2021). Catastrophizing has been postulated as a mechanism that might link depression and pain (Linton & Bergbom, 2011).

Post-traumatic stress disorder

Post-traumatic stress disorder (PTSD) has also long been studied in relation with pain outcomes. Models have been developed to explain the overlap between PTSD and pain, such as the mutual maintenance model (Sharp & Harvey, 2001) and the shared vulnerability model (Asmundson et al., 2002). Numerous investigations have revealed significant correlations between measures of catastrophizing and measures of post-traumatic stress symptoms (PTSS) following deployment (Ciccone & Kline, 2012), whiplash injury (Ravn et al., 2019), or traumatic injury (Giummarra et al., 2017). There is prospective evidence for pain catastrophizing as a unique predictor of PTSS in a variety of populations (Andersen et al., 2016; Carty et al., 2011; Ciccone & Kline, 2012). A number of researchers have found evidence for pain catastrophizing as an important mediator in the cross-sectional and prospective relationship between symptoms of PTSD and pain severity (Carty et al., 2011; Gilliam et al., 2019; Giummarra et al., 2017;

Lopez-Martinez et al., 2014; Martin et al., 2010; Neville et al., 2018; Nordin & Perrin, 2019; Tsur et al., 2017; Vaegter et al., 2017; Van Loey et al., 2018). A study of individuals with acute whiplash injuries found that pain catastrophizing partially mediated the relationship between PTSD and pain at baseline and fully mediated the relationship between PTSD at baseline and pain at 3 months (Andersen et al., 2016).

Although much less empirical research exists to link catastrophic thinking with PTSD outside the realm of pain, theoretical models of PTSD have posited that catastrophizing might play an important role in the development and maintenance of PTSD following a traumatic event (Paunovic, 1998). Catastrophizing as a cognitive emotional regulation strategy was found to be significantly associated with the development of PTSD symptoms in adolescents following a terrorist attack (Jenness et al., 2016). Recent research on military personnel has also found that higher catastrophic thinking was associated with an increased likelihood of developing PTSD (Seligman et al., 2019).

Disability

A growing body of research shows that pain catastrophizing is associated with more pronounced and prolonged disability in individuals with pain conditions. The World Health Organization has defined disability as, "any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions)" (*International Classification of Functioning, Disability and Health (ICF)*, 2001). Although a number of operational definitions of disability exist in pain research, the current thesis focuses on indices of occupational disability, which reflect the important economic and functional losses associated with whiplash injuries (Pink et al., 2016; Sullivan et al., 2017).

Pain catastrophizing has repeatedly been found to be a robust predictor of occupational disability. In fact, the role of pain catastrophizing as a determinant of occupational disability in musculoskeletal pain conditions has been the subject of numerous book chapters, systematic reviews, and meta-analyses (Besen et al., 2015; Schultz et al., 2004; Sullivan et al., 2020; Vargas-Prada & Coggon, 2015). Numerous correlational and prospective studies have shown that high levels of catastrophizing are associated with prolonged work absence in individuals with work-related musculoskeletal injuries (Sullivan et al., 1998; Sullivan et al., 2005). Indeed, pain catastrophizing has been shown to contribute unique variance to the prediction of prolonged work absence following work-related musculoskeletal injuries, even when controlling for other disability-relevant variables (Sullivan et al., 2005).

Similar results have been found in individuals with whiplash injuries. An observational prospective study by Angst et al. (2014) was conducted in individuals with chronic ($\leq$ 3 years) whiplash-associated neck pain participating in a multidisciplinary pain rehabilitation program. A stepwise multivariate regression analysis was conducted to determine which physical health, sociodemographic, or psychosocial variables predicted improvement in working capacity between baseline and a 6-month follow-up. Results from the multivariate regression revealed that baseline pain catastrophizing was the most robust predictor of working capacity at 6 months, following baseline working capacity and pain, and accounted for 5.7% of the variance in working capacity improvement (Angst et al., 2014). Similarly, Carriere, Thibault, Milioto, and Sullivan (2015) investigated the role of several psychosocial risk factors in the prediction of occupational disability for individuals with whiplash injuries. The researchers found that, with each 10-point increase of baseline pain catastrophizing levels, self-reported likelihood of

returning to work at a one-year follow-up decreased by 22 points (Carriere, Thibault, Milioto, et al., 2015).

Knowledge gaps

The pathways through which pain catastrophizing might be contributing to problematic outcomes following whiplash injury have been relatively unexplored to date. It is possible that the role of pain catastrophizing in the development or maintenance of mental health problems might be one pathway through which recovery outcomes are negatively impacted. As mentioned above, the relationship between pain catastrophizing and mental health conditions such as depression and PTSD has been well-established in individuals with whiplash injury (Andersen et al., 2016; Linton & Bergbom, 2011; Ravn et al., 2019). Research has also repeatedly demonstrated that the presence of mental health problems associated with the experience of pain appears to interfere with recovery outcomes (Beck & Clapp, 2011; Borsbo et al., 2009; Buitenhuis et al., 2006; Dunne et al., 2012; Rayner et al., 2016). We propose that pain catastrophizing might increase the cumulative burden of the pain experience by contributing to the development and/or maintenance of symptoms of mental health conditions, such as fatigue, worthlessness, and cognitive difficulties. The burden of pain would likely be augmented as a result of the increased presence of mental health symptoms, thereby increasing the complexity of disability and prolonging the recovery process.

Thesis objective

The present thesis was designed to test to hypothesis that pain catastrophizing has a negative impact on recovery outcomes by increasing the risk of experiencing debilitating mental health symptoms related to depression and PTSD. As such, two studies were conducted to examine this gap in the literature. A first study was conducted to identify the clinical cut-scores

on the Pain Catastrophizing Scale (PCS) indicative of heightened risk for experiencing comorbid depression and/or PTSD. A second objective of Study 1 was to determine whether the presence of clinically significant symptoms of depression and PTSD might act as vehicles through which pain catastrophizing impacts occupational disability. In addition, a second study was conducted to clarify the directional influence of pain catastrophizing on symptoms of mental health problems and pain severity in individuals with whiplash injuries. A discussion of the results of each study is included in their respective manuscripts, followed by a general discussion of the theoretical and clinical implications of the findings of this thesis.

Chapter 2: The relation between level of catastrophizing and mental health comorbidity in individuals with whiplash injuries

Paré C, Thibault P, Côté P, Pimentel SD, Shen S, Yakobov E, Sullivan MJL. The relationship between level of catastrophizing and mental health comorbidity in individuals with whiplash injuries. *Clinical Journal of Pain* 2019;35(11):880-886. doi: 10.1097/AJP.0000000000000749

Abstract

Pain catastrophizing has been shown to be correlated with measures of mental health problems such as depression and PTSD. However, the clinical implications of findings reported to date remain unclear. To date, no study has been conducted to determine meaningful cut-scores on measures of catastrophizing indicative of heightened risk of mental health comorbidity. One objective of the present study was to identify the cut-score on the Pain Catastrophizing Scale (PCS) indicative of heightened risk of the comorbidity of depression and PTSD. A second objective was to determine whether mental health comorbidity mediated the relation between catastrophizing and occupational disability. The sample consisted of 143 individuals with whiplash injuries. Pain severity, pain catastrophizing, depression, and post-traumatic stress symptoms were assessed following admission to a rehabilitation program. Mental health comorbidity was operationally defined as obtaining a score above clinical threshold on measures of depressive and/or post-traumatic stress symptom severity. ROC curve analysis revealed that a PCS score of 22 best distinguished between participants with and without mental health comorbidity. Results also revealed that mental health comorbidity mediated the relation between catastrophizing and occupational disability. The findings suggest that a score of 22 or greater on the PCS should alert clinicians to the possibility that patients might also be experiencing clinically significant symptoms of depression or PTSD. Greater attention to the detection and treatment of mental health conditions associated with whiplash injury might contribute to more positive recovery outcomes.

Introduction

Whiplash injury is associated with the highest costs of all injuries incurred in motor vehicle collisions (Cassidy et al., 2000; Pink et al., 2016; Quinlan et al., 2004). The yearly economic burden of whiplash injury in North America, arising from health care costs, lost productivity, wage replacement, and litigation, is estimated to be in excess of 250 billion dollars (Blincoe et al., 2002; Foreman & Croft, 2002). As many as 50% of individuals who have sustained whiplash injuries will remain symptomatic one year following injury, with 15-20% of cases resulting in permanent occupational disability (Carroll et al., 2008; Sterling, 2016).

Pain catastrophizing has emerged as one of the most robust psychosocial predictors of problematic recovery following whiplash injury (Sarrami et al., 2017; Sullivan et al., 2011). Pain catastrophizing has been broadly defined as an exaggerated negative orientation towards actual or anticipated pain, comprising elements of rumination, magnification, and helplessness (Sullivan et al., 1995; Sullivan, Thorn, et al., 2001). Several cross-sectional and prospective studies have shown that pain catastrophizing is associated with several adverse health and mental health outcomes in individuals who have sustained whiplash injuries (Laporte et al., 2016; Ritchie & Sterling, 2016; Smith et al., 2013).

Gellatly and Beck (2016) have proposed that catastrophizing might be a risk factor for the onset and maintenance of symptoms of psychological disorders such as depression and PTSD (Gellatly & Beck, 2016). Consistent with this view, numerous investigations have revealed significant relations between measures of catastrophizing and measures of depression and PTSD (Andersen et al., 2016; Casey et al., 2015; Gilliam et al., 2017). The results of previous investigations have shown moderate to high correlations between pain catastrophizing and depression (Burns et al., 2003; Geisser et al., 1994; Gilliam et al., 2017; Hulsebusch et al., 2016),

and high correlations between pain catastrophizing and post-traumatic stress symptoms (Ciccone & Kline, 2012; Giummarra et al., 2017; Sullivan et al., 2016).

The clinical implications of research conducted to date are unclear. Significant correlations between variables do little to assist clinicians in identifying individuals who might be at risk for co-occurrence of mental health problems. Two variables can be correlated yet still fall below clinical thresholds. To date, no study has been conducted to determine meaningful cut-scores on measures of catastrophizing that would indicate heightened risk of the comorbidity of mental health problems.

The primary aim of the present study was to identify the clinical cut-scores on the Pain Catastrophizing Scale (PCS) indicative of heightened risk of the comorbidity of depression and PTSD. A second objective of the present study was to determine whether the presence of clinically significant symptoms of depression and PTSD might act as vehicles through which pain catastrophizing might impact occupational disability. While numerous studies have reported a relation between catastrophizing and pain-related disability in individuals with whiplash injuries, the processes by which catastrophizing impacts on disability have not been clarified. There is little within the item-content of measures of pain catastrophizing that suggests how catastrophizing might contribute to disability. However, the symptoms of mental health problems such as loss of interest, psychomotor slowing, and avoidance could be expected to interfere with an individual's ability to fully participate in many domestic, social, recreational, and occupational activities.

The study objectives were addressed using a prospective cohort of individuals with whiplash injuries who were enrolled in a functional restoration rehabilitation program. Participants completed measures of pain severity, pain catastrophizing, depressive symptoms,

and post-traumatic stress symptoms at the time of admission. Occupational status was assessed one year following termination of the rehabilitation program. Receiver operating characteristic (ROC) curve analysis was used to determine the cut-score on the PCS that best distinguished between participants with or without scores above clinical threshold on measures of depression and/or PTSD. Regression analysis was used to assess whether the co-occurrence of clinically significant depression or PTSD mediated the relation between catastrophizing and occupational disability.

Method

Participants

Participants were recruited from 6 pain rehabilitation clinics specializing in the treatment of whiplash injuries in the province of Quebec, Canada. Individuals were considered for participation if they had received a diagnosis of Whiplash Associated Disorder (WAD) grade II. All participants had been employed prior to their injury and were receiving salary indemnity through a no-fault provincial insurance system (*Société de l'assurance automobile du Québec;* SAAQ). Of the 146 individuals who were enrolled in the study, 98.6% (101 women, 43 men) completed all measures and 97.9% (100 women, 43 men) were successfully contacted for the final assessment. The mean age of the sample was 36.26 years (SD = 9.86 years), and the mean duration of work-disability at the time of enrolment was 9.40 weeks (SD = 5.48).

Procedure

The research program was approved by the Institutional Review Board of McGill University. Participants signed a consent form prior to completing the study procedures. Participants were asked to complete measures of pain severity, pain catastrophizing, depressive symptomatology, and post-traumatic stress symptoms as part of their initial assessment. At a

one-year follow-up, participants were contacted by phone and asked to report their occupational status. Participants were compensated $50 for completing the questionnaires and the follow-up interview.

Participants were enrolled in a standardized 7-week multidisciplinary functional restoration rehabilitation program. The rehabilitation program conformed to practice guidelines for early intervention for musculoskeletal problems consistent with reimbursement policies of the SAAQ, emphasizing mobilization and activity (Sullivan, Thibault, et al., 2009). Intervention teams consisted of a physiotherapist, an occupational therapist, and a psychologist. The education and self-management components of the intervention were provided in group format, and the exercise component of the intervention was individually tailored to participants' needs.

Measures

Pain severity

Participants were asked to complete the Pain Rating Index of the McGill Pain Questionnaire (MPQ-PRI) to assess their current pain severity. Participants were asked to endorse pain adjectives that best describe their pain experiences. The MPQ-PRI is derived as the weighted sum of the pain adjectives that were endorsed. Scores on the MPQ-PRI range from 0 to 78 (higher scores indicating more severe pain). The MPQ-PRI has been shown to be a reliable and a valid index of an individual's pain experience (Turk et al., 1985).

The distribution of pain sites was assessed using a schematic body drawing. The body drawing was subdivided into 45 different areas, which were combined to represent four anatomical categories: 1) neck, 2) back, 3) upper extremities, and 4) lower extremities. Participants were asked to shade areas corresponding to body sites where they experienced pain.

If an area was left blank, a score of 0 was given. A total score for number of pain sites for each participant was derived by summing the values in each of the four anatomical categories.

Pain catastrophizing

The Pain Catastrophizing Scale (PCS) was used to assess catastrophic thinking related to pain (Sullivan et al., 1995). The PCS consists of 13 items describing different thoughts and feelings that individuals might experience when they are in pain. The PCS has high internal consistency, and has been shown to be associated with heightened pain and disability as well as poor occupational outcomes (Sullivan et al., 1995; Sullivan et al., 1998; Sullivan & Stanish, 2003).

Depression

The Beck Depression Inventory-II (BDI-II) was used as a self-report measure of depressive symptom severity (Beck et al., 1996). The BDI-II consists of 21 items describing various symptoms of depression, and participants chose one of four statements that best describes how they have been feeling in the last two weeks (Beck et al., 1996). Elevated scores on the BDI-II have been shown to be an important predictor of adverse pain-related outcomes (Boersma & Linton, 2006). Research has supported the validity and reliability of the BDI-II as a measure of depressive severity (Bishop et al., 1993). A recent meta-analysis of the psychometric properties of the BDI-II recommended a cut-score of 13 for the classification of clinically significant depression (Erford et al., 2016). A cut-score of 13 on the BDI-II has been shown to have an average sensitivity value of .83, an average specificity of .76, and an average positive predictive value of .66 (Erford et al., 2016).

Post-traumatic stress symptoms

The Impact of Event Scale - Revised (IES-R) was used to assess symptoms of post-traumatic stress. On this measure, participants are asked to rate the degree of distress they experience in relation to different cognitive and emotional aspects of post-traumatic stress. Ratings are made on a 5-point scale with the endpoints (0) *not at all* and (4) *extremely* (Weiss & Marmar, 1997). The IES-R has been shown to be a reliable and valid measurement for discriminating between individuals with and without a diagnosis of PTSD (Beck et al., 2008; Brunet et al., 2002). A cut-score of 33 has been recommended as the threshold for clinically significant post-traumatic stress symptoms (Creamer et al., 2003). A cut-score of 33 has been shown to have a sensitivity of 0.91, a specificity of 0.82, and a positive predictive value of 0.90 (Creamer et al., 2003).

Follow-up interview

One year following the termination of the rehabilitation intervention, participants were contacted by telephone to answer questions regarding their employment status. For the purposes of this paper, current employment status was categorized as (1) *resumed with full- or part-time work* or (2) *work-disabled*.

Data analytic approach

Portions of these data were previously published in a report addressing the relation between expectancies and return to work outcomes (Carriere, Thibault, & Sullivan, 2015).

There were no significant differences on any of the baseline variables across recruitment sites. As such, analyses were conducted collapsed across all 6 rehabilitation clinics from which participants were recruited.

T-tests for independent samples and chi-square analyses were used to compare men and women on demographic and pain-related variables. Pearson correlations were used to examine relations among measures of pain catastrophizing, pain severity, depressive symptoms, and post-traumatic stress symptoms.

Mental health comorbidity was defined as clinically significant symptoms of depression, PTSD or both. A cut-score of 13 on the BDI-II was used to classify participants as experiencing depressive symptoms above clinical threshold (Erford et al., 2016). A cut-score of 33 on the IES-R was used to classify participants as experiencing post-traumatic stress symptoms above clinical threshold (Creamer et al., 2003). Logistic regression was used to assess the value of pain catastrophizing scores in predicting mental health comorbidity.

A Receiver Operating Characteristic (ROC) curve analysis was used to identify the score on the PCS that best distinguished between participants with and without mental health comorbidity (Zweig & Campbell, 1993). The optimal cut-score on the PCS was chosen at the point which maximized the Area Under the Curve (AUC) generated by the ROC curve analysis. This approach has previously been used to identify clinically meaningful scores on pain-related variables (Farrar et al., 2001).

Logistic regression was also used to assess the predictive value of mental health comorbidity for estimating employment status. Of interest was whether mental health comorbidity predicted rehabilitation outcomes beyond the variance accounted for by pain catastrophizing. Tolerance coefficients for variables included in the regression analyses were greater than .60, indicating no problem of multicollinearity. All analyses were conducted with SPSS Version 24.

Results

Sample characteristics

Demographic information for the sample at admission is presented in **Table 1**. Women and men differed significantly in their level of education ($\chi^2 = 13.80$, $p = .008$) and their employment ($\chi^2 = 34.75$, $p = .000$). No other significant gender differences were found on any sample characteristics.

Correlations among measures

Means and standard deviations of pain-related variables are presented in **Table 2.** No significant gender differences were found on any pain-related variables; as such, means and correlations of pain-related variables for men and women are not reported separately. Pre-treatment mean scores on pain catastrophizing, depression, and post-traumatic stress symptoms were comparable (within 1 standard deviation) to those reported in previous research with individuals who have sustained whiplash injuries (Slepian et al., 2014; Sullivan, Thibault, et al., 2009). The study sample would be characterized as experiencing pain of moderate severity, and depressive and post-traumatic stress symptoms of mild severity.

Correlations between psychological and pain-related variables are also reported in **Table 2**. Consistent with previous research, scores on the PCS were significantly correlated with measures of pain severity (r = .31), depressive symptoms (r = .44), and post-traumatic stress symptoms (r = .63) (Linton et al., 2011; Sullivan, Thibault, et al., 2009; Sullivan, Thorn, et al., 2001; Thompson et al., 2010). Also consistent with previous research, scores on the BDI-II and the IES-R were significantly correlated with measures of pain severity (r = .34 and r = .29, respectively) (Lopez et al., 2013; Sullivan et al., 2016).

Level of catastrophizing and mental health comorbidity

A cross-sectional logistic regression was conducted to assess the contribution of pre-treatment PCS scores to the prediction of the presence or absence of comorbid mental health problems at admission. In univariate analyses, pain severity, but not number of pain sites or pain duration, was significantly related to mental health comorbidity. As such, only pain severity was included as a pain-related covariate in the regression model. As shown in **Table 3**, age and gender were entered in the first step of the analysis and did not contribute significantly to the prediction of mental health comorbidity ($\chi^2 = 0.71$, $p = .701$). Pain severity was entered in the second step of the analysis and contributed significantly to the prediction of mental health comorbidity ($\chi^2 = 9.42$, $p = .002$). In the final step of the analysis, PCS scores were entered and contributed significantly to the prediction of mental health comorbidity ($\chi^2 = 27.45$, $p = .000$). In the final regression analysis, only PCS scores (OR = 1.12, $p = .000$, 95% CI = 1.07 – 1.18) contributed significant unique variance to the prediction of mental health comorbidity. The results indicate that, for every unit increase in PCS scores, participants were 1.12 times more likely to be experiencing a comorbid mental health problem.

Figure 1 shows the incremental probability of mental health comorbidity as a function of level of catastrophizing. A PCS score from 21-30 (out of 52) was associated with an 76% probability of having a mental health comorbidity, whereas a PCS score from 31-40 was associated with a 91% probability of having a mental health comorbidity. A PCS score above 40 was associated with a 100% chance of experiencing a comorbid mental health condition. ROC curve analysis revealed that a pain catastrophizing score of 22 best distinguished between participants with and without a mental health comorbidity (AUC = .76, p = .000, 95% CI = .68 – .84).

Comorbidity and treatment outcomes

A logistic regression was conducted to examine whether mental health comorbidity at admission contributed to the prediction of return to work (RTW), beyond the variance accounted for by pain catastrophizing. In univariate analyses, demographic variables (age, gender), pain-related variables (pain severity, number of pain sites, pain duration), and psychosocial variables (pain catastrophizing, mental health comorbidity) were significantly related to RTW outcomes. As such, all of these variables were included as covariates in the regression model. As shown in **Table 4,** age and gender were entered in the first step of the analysis and did not contribute significantly to the prediction of RTW status at follow-up ($\chi^2 = .08$, $p = .959$). The number of pain sites, pain duration, and pre-treatment pain severity were entered in the second step of the analysis and did not contribute significantly to the prediction of RTW at follow-up ($\chi^2 = 1.49$, $p = .685$). Pre-treatment PCS scores were entered in the third step of the analysis and contributed significantly to the prediction of RTW status at follow-up ($\chi^2 = 4.05$, $p = .044$). Mental health comorbidity at admission was entered as the fourth step of the analysis and contributed significantly to the prediction of RTW ($\chi^2 = 10.24$, $p = .001$). In the final regression analysis, only mental health comorbidity contributed significant unique variance to the prediction of RTW status at follow-up (OR = 4.13, $p = .002$, 95% CI = 1.66 – 10.25). The results indicate that participants experiencing clinically significant levels of depression and/or PTSD symptomatology were 4.13 times more likely to remain work-disabled at the one-year follow-up. Sobel's test revealed that the relationship between pain catastrophizing and RTW at a one-year follow-up was mediated by mental health comorbidity (t = 20.14, SE = 9.63, p < .00).

Discussion

The findings of the study are consistent with previous research showing that measures of pain catastrophizing and measures of depressive and post-traumatic stress symptoms are significantly correlated (Linton et al., 2011; Sullivan, Thibault, et al., 2009; Sullivan, Thorn, et al., 2001; Thompson et al., 2010). The results of the present study extend previous findings by highlighting the clinical relevance of the relation between catastrophizing and symptoms of mental health problems. The results suggest that a cut-score of 22 on the PCS best distinguished between individuals with and without mental health comorbidity. As well, findings revealed that mental health comorbidity mediated the relationship between pain catastrophizing and prolonged occupational disability.

Several previous investigations have examined the inter-relations between measures of pain catastrophizing and measures of mental health symptom severity (Andersen et al., 2016; Edwards et al., 2016; Sullivan, Rodgers, et al., 2001). In the present study, indices of mental health comorbidity were derived to address the clinical significance of the relation between pain catastrophizing and symptoms of mental health problems. Mental health comorbidity was operationally defined as a score above clinical threshold on the BDI-II and/or the IES-R. Participants were considered to be experiencing a comorbid mental health problem if they obtained a score of 13 or above on the BDI-II (≥13), a score of 33 or above on the IES-R (≥33) or both. A logistic regression revealed that pain catastrophizing was significantly associated with mental health comorbidity. Participants whose score on the PCS was 21 or above at admission had an 84% chance of also experiencing clinically significant depressive and/or PTSD symptoms.

Cognitive models of emotional disorders propose that catastrophizing might act as an antecedent or causal variable in the development or maintenance of symptoms of depression and PTSD. For example, Beck et al. (1978) discussed catastrophizing as a maladaptive cognitive appraisal that negatively impacts mood and increases susceptibility to depression (Beck et al., 1979). More recently, Gellatly and Beck (2016) have proposed that catastrophizing might represent a transdiagnostic cognitive style that contributes to increased risk of developing a wide range of mental health problems. They suggest that, while the specific content of catastrophic thinking might vary across mental health conditions, cognitive processes triggered by catastrophizing such as interpretive bias, attentional bias, and attentional fixation might act as vulnerability factors common across mental health conditions (Gellatly & Beck, 2016).

When the severity of symptoms of depression or PTSD rises above clinical threshold, the symptoms of these mental health problems might add to the burden of disability associated with whiplash injury. For example, physical symptoms of depression, such as insomnia (item 16 of the BDI-II) and fatigue (item 18), as well as cognitive and emotional symptoms, such as pessimism (item 2) and worthlessness (item 3), might impact negatively on individuals' ability to perform many activities of daily living. Similarly, the sleep (items 2, 15, and 20 of the IES-R), emotional (items 4, 5, 12, 13, and 16), and cognitive (item 18) difficulties that make up the symptom profile of PTSD might also compromise an individual's full participation in the important activities of their life, including work.

The results of a logistic regression revealed that mental health comorbidity mediated the relation between catastrophizing and prolonged work absence. Participants who were classified as having a mental health comorbidity were over 4 times more likely to remain work-disabled at the one-year follow-up. Although catastrophizing predicted prolonged work absence in

univariate analyses, catastrophizing was no longer a significant predictor of prolonged work absence when mental health comorbidity was included in the regression analysis.

Findings linking pain catastrophizing to problematic recovery outcomes over the past two decades have provided the impetus for the development of interventions specifically designed to reduce pain catastrophizing (Burns et al., 2012; Burns et al., 2003; Sullivan, Adams, et al., 2006; Sullivan & Stanish, 2003; Turner et al., 2007). The content and structure of these interventions has varied widely, ranging from information-based web applications to psychosocial interventions delivered by trained professionals (Burns et al., 2012; Burns et al., 2003; Smeets et al., 2006; Spinhoven et al., 2004; Vowles et al., 2004; Vowles et al., 2007). Interventions targeting pain catastrophizing have generally ranged in duration from 4-10 weeks (Sullivan, Adams, et al., 2006; Sullivan & Stanish, 2003; Vowles et al., 2004). However, a recent review by Schutze et al. (2018) concluded that interventions used to reduce pain catastrophizing have yielded only modest outcomes, with many studies showing that the changes in pain catastrophizing have been too small to be clinically significant (Schutze et al., 2018). Mental health comorbidity might be a factor relevant to the modest impact of treatments aimed at reducing pain catastrophizing (Gardner-Nix et al., 2008; Schutze et al., 2018; Smeets et al., 2006; Turner et al., 2016; Williams et al., 2012). If high scores on measures of pain catastrophizing reflect a high probability of mental health comorbidity, it is likely that current educational or web-based interventions targeting catastrophizing might not be sufficient to yield clinically meaningful improvement for individuals experiencing comorbid mental health problems. Treatment might maximize recovery outcomes by targeting symptoms of mental health disorders, such as depression or PTSD, in addition to targeting pain catastrophizing. However, not all individuals experiencing high levels of pain catastrophizing also experience comorbid

mental health difficulties such as depression and PTSD. Future research should explore whether treatment might benefit from a stratified-care approach, wherein treatment for individuals with high pain catastrophizing scores is tailored based on whether they are also experiencing comorbid mental health problems.

There are important clinical implications to the findings of the present study. The findings suggest that high scores on a measure of pain catastrophizing should alert clinicians that clients may be experiencing a comorbid mental health problem. A high score on a measure of pain catastrophizing should prompt clinicians to pursue a more in-depth evaluation of the client's mental health status. The findings of the present study might be particularly relevant to unidisciplinary primary care services where measures of catastrophizing might be routinely administered but the routine administration of measures of mental health symptoms might be less common. For example, the assessment of mental health problems would be considered beyond the domain of expertise of disciplines such as physiotherapy or kinesiology. In settings where there are challenges to routine assessment of mental health problems, high scores on self-report measures of catastrophizing would indicate the need for referral to a mental health professional for further assessment and treatment.

Caution should be exercised in the interpretation of the present findings. The present study operationalized mental health comorbidity on the basis of scores on self-report measures as opposed to structured diagnostic interview. Although the bulk of research on depression and PTSD associated with whiplash injury has been conducted using self-report measures, the diagnostic interview is considered the gold standard for the diagnosis of mental health disorders. Considerable research attests to the validity of the BDI-II and the IES-R as measures of mental health problems associated with pain (Lopez et al., 2013; Sullivan et al., 2016). However, there

is research to suggest that, while self-report measures of depressive and post-traumatic stress symptomatology have high sensitivity for diagnoses of Major Depressive Disorder (MDD) and PTSD, the specificity of these measures is low (Mouthaan et al., 2014; Thombs et al., 2018). As such, it is not possible to determine which participants met diagnostic criteria for MDD or PTSD. Confidence in the findings of the present study awaits replication using structured diagnostic interviews. In addition, all participants in the present study were recruited from rehabilitation centers. Only a minority of individuals with whiplash injuries are referred to rehabilitation centers. It is possible that patients who are considered for referral to a rehabilitation center might present with more complex problem profiles, which may have implications for the generalizability of findings. It is also necessary to consider that a wide range of individual differences and workplace factors which have been shown to impact on occupational outcomes were not assessed in this study. Whether the contribution of catastrophizing and mental health problems to occupational outcomes is independent of other individual differences or workplace factors remains to be clarified by future research. Finally, the correlational nature of the study places limits on the causal inferences that can be made about the relation between pain catastrophizing and mental health comorbidity.

In spite of these limitations, the results of the present study showed that high levels of pain catastrophizing are associated with the presence of comorbid mental health problems in individuals with whiplash injuries. The results also showed that mental health comorbidity contributed significantly to poor occupational outcomes in whiplash-injured individuals, beyond the variance accounted for by level of pain catastrophizing. The findings suggest that high scores on measures of pain catastrophizing should prompt further investigation of the possible presence of mental health problems such as depression or PTSD. Greater attention to the detection and

treatment of mental health conditions associated with whiplash injury might contribute to more positive recovery outcomes in individuals with whiplash injuries who obtain high pain catastrophizing scores.

Acknowledgements

This research was supported by funds from the Canadian Institutes for Health Research (CIHR), and the Canada Research Chairs program. The authors thank Elena Bernier for her assistance in data collection and data entry.

Tables and Figures

Table 1

Sample characteristics (N=144).

Characteristics	**Women (n = 101)**	**Men (n = 43)**	***p***
Age	36.85 (9.93)	34.86 (9.68)	n.s.
Number of pain sites (/4)	2.89 (0.76)	2.79 (0.83)	n.s.
Marital status			n.s.
Single	25 (25%)	18 (42%)	
Common law	31 (30%)	11 (26%)	
Married	24 (24%)	9 (21%)	
Separated/divorced	21 (21%)	4 (9%)	
Widow	0 (0%)	1 (2%)	
Education			.008
Less than high school	13 (13%)	12 (28%)	
High school	25 (25%)	17 (40%)	
Trade school	19 (19%)	7 (16%)	
College	31 (30%)	3 (7%)	
University	13 (13%)	4 (9%)	
Occupation			.000
Laborer	19 (19%)	20 (47%)	

Nursing	38 (38%)	0 (0%)	
Clerical	22 (22%)	6 (14%)	
Driver	2 (2%)	5 (12%)	
Trade	15 (15%)	7 (16%)	
Sales	5 (5%)	4 (9%)	
Student	0 (0%)	1 (2%)	

Table 2

Correlations with means and standard deviations between pain and psychological measures.

	Mean (SD)	**1.**	**2.**	**3.**	**4.**
1. Pain duration (weeks)	9.44 (5.48)	-	-	-	-
2. MPQ	22.51 (13.18)	.06	-	-	-
3. PCS	22.07 (10.71)	.04	.31**	-	-
4. BDI-II	15.43 (9.35)	.12	.34**	.44**	-
5. IES-R	34.40 (22.75)	.11	.29**	.63**	.66**

Note: N = 144. MPQ = McGill Pain Questionnaire. PCS = Pain Catastrophizing Scale. BDI-II = Beck Depression Inventory – II. IES-R = Impact of Events Scale – Revised. Two female participants did not respond to the MPQ and three female participants did not complete the BDI-II. * $p < .05$; ** $p < .01$

Table 3

Logistic regression examining predictors of the presence of mental health comorbidity at pretreatment.

Step	Variable added at each step	Wald	OR	*p*	95%CI
1	Age	3.53	0.96	.060	0.922 – 1.002
	Gender	0.79	0.67	.373	0.280 – 1.612
2	MPQ	2.84	1.03	.092	0.995 – 1.066
3	PCS	20.74	1.12	.000	1.066 – 1.175

Note: N = 144. MPQ = McGill Pain Questionnaire. PCS = Pain Catastrophizing Scale. OR = Odds ratio. 95% CI = 95th percentile confidence interval. Two female participants did not respond to the MPQ.

Table 4

Logistic regression examining pretreatment predictors of rehabilitation outcomes (RTW).

Step	Variable added at each step	Wald	OR	*p*	95%CI
1	Age	0.17	1.01	.682	0.971 – 1.046
	Gender	0.03	1.07	.865	0.488 – 2.350
2	Pain duration (weeks)	0.05	0.99	.828	0.930 – 1.059
	Number of pain sites (0-4)	0.25	0.93	.764	0.571 – 1.508
	MPQ	0.00	1.00	.958	0.973 – 1.030
3	PCS	0.45	1.01	.504	0.975 – 1.052
4	Comorbidity (Y/N)	9.35	4.13	.002	1.664 – 10.245

Note: N = 144. MPQ = McGill Pain Questionnaire. PCS = Pain Catastrophizing Scale. OR = Odds ratio. 95% CI = 95th percentile confidence interval. Two female participants did not respond to the MPQ and one female participant did not indicate RTW status.

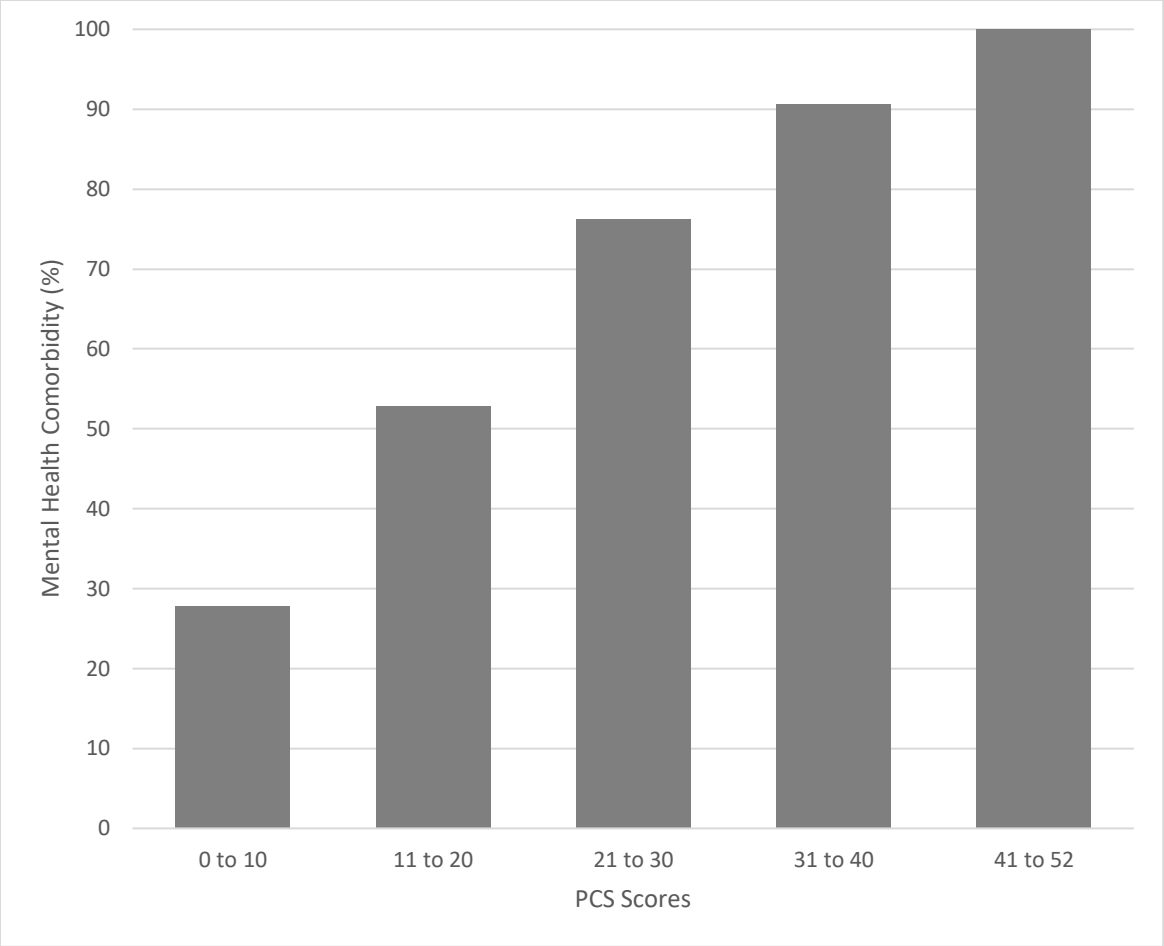

Figure 1. Prevalence of clinically significant mental health comorbidity as a function of increasing PCS scores. N = 144. PCS = Pain Catastrophizing Scale.

Preface to Chapter 3

Study 1 had two objectives: first, to identify the cut-score on the PCS indicative of heightened risk of the comorbidity of depression and PTSD. A second aim of Study 1 was to determine whether mental health comorbidity was a pathway through which pain catastrophizing impacted occupational disability. Findings revealed that a PCS score of 22 best distinguished between participants with and without mental health comorbidity. In addition, findings support that mental health comorbidity significantly predicted whether participants had returned to work 1 year following injury, above and beyond the impact of pain catastrophizing.

The results of Study 1 join a growing body of literature demonstrating that pain catastrophizing is associated with adverse mental health outcomes in individuals with whiplash injuries. Based on the findings of Study 1, it is tempting to propose that interventions targeting pain catastrophizing might prevent the development of depression or PTSD and, in turn, improve pain-related outcomes following whiplash injury. However, there have been no studies conducted to date that have examined the possible causal or antecedent role of pain catastrophizing on the development or persistence of mental health problems following whiplash injury. As such, the aim of Study 2 was to examine the sequential relationship between pain catastrophizing, pain severity, depressive symptoms, and PTSD symptoms. Findings of Study 2 were expected to elucidate the potential causal role of pain catastrophizing in predicting mental health symptoms (i.e., of depression and PTSD) and pain-related outcomes (i.e., pain severity) in individuals who have sustained a whiplash injury.

Chapter 3: Temporal relations between pain catastrophizing and adverse health and mental health outcomes following whiplash injury

Paré, C, Yamada, K, Sullivan, MJL. Temporal relations between pain catastrophizing and adverse health and mental health outcomes following whiplash injury. *Clinical Journal of Pain* (submitted).

Abstract

Pain catastrophizing has been shown to be a prognostic indicator for pain severity and the co-occurrence of mental health conditions such as depression and Post-Traumatic Stress Disorder (PTSD) following whiplash injury. However, the pattern of available findings is limited in its implications for the possible 'antecedent' or 'causal' role of pain catastrophizing. The purpose of the present study was to examine the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and post-traumatic stress symptoms (PTSS) in individuals receiving treatment for whiplash injury. The sample consisted of 388 individuals enrolled in a multidisciplinary program for whiplash injury. Participants completed self-report measures of pain catastrophizing, pain severity, depressive symptoms, and PTSS at the time of admission, mid-treatment (4 weeks), and upon treatment completion (7 weeks). A cross-lagged panel analysis was used to examine the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and PTSS across all three timepoints. Model fit was acceptable following the inclusion of modification indices. Pain catastrophizing at the time of admission predicted all other variables at 4 weeks. Pain catastrophizing at 4 weeks also predicted all other variables at 7 weeks. In addition, some bidirectional relations were present, particularly later in the course of treatment. Findings support the view that pain catastrophizing might play a transdiagnostic role in the onset and maintenance of health and mental health conditions. The findings call for greater emphasis on the development of treatment techniques which target pain catastrophizing in intervention programs for whiplash injury.

Introduction

Whiplash injury arising from motor vehicle collisions is associated with nearly 2 million emergency department visits per year in North America (Niska et al., 2010). As many as 50% of individuals who have sustained whiplash injuries will remain symptomatic one year following injury (Carroll et al., 2008; Sterling, 2016). In North America, the yearly economic burden of whiplash injury arising from health care costs, lost productivity, wage replacement, and litigation is estimated to be in excess of 250 billion dollars (Blincoe et al., 2002; Foreman & Croft, 2002).

Pain catastrophizing has emerged as one of the most robust psychological predictors of problematic recovery following whiplash injury (Sullivan et al., 2011; Walton et al., 2013). Research suggests that pain catastrophizing accounts for 7% to 31% of the variance in measures of pain severity (Ritchie & Sterling, 2016; Sullivan, Thorn, et al., 2001). Gopinath and colleagues reported that each unit increase on a baseline measure of pain catastrophizing was associated with a 0.5/10 unit increase in pain severity at 12 months post-injury (Gopinath et al., 2015). Numerous cross-sectional and prospective studies have reported that high levels of pain catastrophizing also predict more severe and prolonged symptoms of depression and post-traumatic stress symptoms (PTSS) following whiplash injury (Andersen et al., 2016; Carstensen, 2012; Laporte et al., 2016; Nieto et al., 2011; Sarrami et al., 2017). A recent cross-sectional study of individuals with whiplash injuries showed that 80% of participants with a score of 21 or greater on the Pain Catastrophizing Scale also scored above clinical threshold on measures of depression and PTSS (Paré et al., 2019).

It has been suggested that pain catastrophizing might play a causal role in delayed or adverse recovery outcomes following whiplash injury (Andersen et al., 2016; Bostick et al., 2013; Sullivan et al., 2011). Although the pattern of findings that has emerged from previous

research supports a relation between catastrophizing and problematic recovery outcomes following whiplash injury, research to date is limited in its implications for the possible causal role of pain catastrophizing.

Cross-lagged panel analyses are considered a useful analytic approach for clarifying the directions of influence between variables (Kearney, 2017). Cross-lagged panel analyses control for autoregressive (i.e., the stability of the same variable across time) and synchronous (i.e., the correlations within a time-point) effects (Selig & Little, 2012). It is crucial to control for extraneous sources of variance from autoregressive and synchronous effects, as these can influence findings of prospective analyses. To date, no study has been conducted using cross-lagged panel analyses to clarify the direction of influence between pain catastrophizing and adverse recovery outcomes in individuals with whiplash injuries.

The purpose of the present study was to examine the role of pain catastrophizing as a determinant of pain, depression, and PTSS in individuals who had sustained whiplash injuries. Of interest was to examine the temporal relation between changes in pain catastrophizing and changes in pain, depression, and PTSS in a sample of individuals with whiplash injuries participating in a rehabilitation intervention. A crossed-lagged panel design was used to examine the relation between early and late treatment-related changes in pain catastrophizing and pain, depression, and PTSS. Proceeding from previous research showing that pain catastrophizing is prospectively related to adverse recovery outcomes, it was hypothesized that early changes in pain catastrophizing would predict later changes in pain severity, depressive symptoms, and PTSS.

Methods

Participants

388 participants were recruited from one of 6 multidisciplinary pain treatment clinics in the Greater Montreal area between June 2012 and August 2015. Individuals were considered for participation in the present study if they had been injured in rear-impact motor vehicle collisions. Eligibility criteria for enrolment in the rehabilitation program included a diagnosis of a whiplash-associated disorder (grade II) and being absent from work at the time of recruitment. All participants were receiving salary indemnity through a no-fault provincial insurance system (Société de l'assurance automobile du Québec, SAAQ).

Procedures

The Ethics Review Board of *McGill University* approved the current study. Participants were recruited from clinics that were part of a health network providing rehabilitation services for the state motor vehicle insurer (SAAQ). Treatment was standardized and extended over a period of 7 weeks. The rehabilitation program consisted of medication management, education, exercise, and instruction in the use of self-management skills. Participants were recruited through advertisements placed in the waiting rooms of the clinics where participants were being treated. Recruitment advertisements provided information about the study and the contact information for the study coordinator.

Participants signed a consent form prior to enrolling in the study. Participants provided demographic information and completed self-report measures of pain catastrophizing, pain severity, depressive symptoms, and PTSS at the time of admission (T1). Participants completed the same self-report measures again at mid-treatment (4 weeks, T2) and upon treatment

completion (7 weeks, T3). Participants were compensated $25 for completing the questionnaires at each timepoint.

Measures

Pain catastrophizing

The Pain Catastrophizing Scale (PCS) was used to assess catastrophic thinking in relation to pain (Sullivan et al., 1995). The PCS comprises 13 items describing different thoughts and feelings individuals might have when experiencing pain. The frequency of these thoughts and feelings are rated on a 5-point scale with the endpoints (0) *not at all* and (4) *all the time*. A recent meta-analysis of 220 studies found that the PCS had good internal consistency (Cronbach's alpha = 0.92, 95% CI = 0.91-0.93) as well as test-retest reliability (0.88, 95% CI = 0.83-0.93) (Wheeler et al., 2019).

Pain severity

A numerical rating scale (NRS) with the endpoints (0) *no pain at all* and (10) *excruciating pain* was used to assess participants' current pain severity. Research supports the use of NRS as valid and reliable measures of pain severity (Boonstra et al., 2016; Hjermstad et al., 2011; Jensen et al., 1999). The NRS has also shown to be a more responsive measure of pain severity when compared to other similar pain severity rating scales (Ferreira-Valente et al., 2011).

Depressive symptoms

The Beck Depression Inventory-II (BDI-II) was used to assess self-reported depressive symptom severity (Beck et al., 1996). The BDI-II consists of 21 questions assessing different aspects of depressive symptomatology (e.g., motivation, loss of interest, self-criticism). A recent meta-analysis of the BDI-II from 144 studies revealed good internal consistency (Cronbach's

alpha = 0.89, 95% CI = 0.88-0.91), good test-retest reliability (0.75, 95% CI = 0.69-0.81), and convergent validity (ranging from .45 to .88) (Erford et al., 2016).

Post-traumatic stress symptoms

Post-traumatic stress symptoms (PTSS) were assessed using the Impact of Event Scale-Revised (IES-R) (Weiss & Marmar, 1997). Participants were asked to rate the distress they experienced regarding different cognitive and emotional aspects of post-traumatic stress using a 5-point scale with the endpoints (0) *not at all* and (4) *extremely*. The IES-R has been shown to have high internal consistency (Cronbach's alpha = 0.95-0.96) (Beck et al., 2008; Creamer et al., 2003) and test-retest reliability (0.89-0.94) (Weiss & Marmar, 1997). Research shows that the IES-R is a reliable and valid measure for discriminating discriminates between individuals with and without a diagnosis of PTSD (Beck et al., 2008; Brunet et al., 2002).

Data analysis

A portion of the data used in the present study was previously published in a paper examining the role of mental health problems as a mediator of the relation between pain catastrophizing and occupational disability (Paré et al., 2019).

There were no significant differences due to recruitment site on any of the study variables. As such, analyses were conducted collapsed across all 6 rehabilitation clinics from which participants were recruited. An assessment of the missing data and distribution of the data was conducted. Of the 388 participants that made up the study sample, 29 (7.5%) were missing responses to one or more of the primary study variables (pain catastrophizing, pain severity, depressive symptoms, PTSS) for at least one of the study timepoints (admission, mid-treatment, treatment completion). Full-information maximum likelihood (FIML) was used to address any issues of missing data based on the missing-at-random assumption to ensure the full use of the

dataset for the cross-lagged panel model. In addition, skewness and kurtosis values indicated that values included in the cross-lagged panel model were normally distributed.

Descriptive analyses, t-tests, and correlations were conducted using SPSS Version 27. Means and standard deviations as well as frequency counts were calculated for study variables. Independent samples t-tests were used to compare men and women on demographic variables as well as on measures of pain catastrophizing, pain severity, depressive symptoms, and PTSS at baseline. Pearson correlations were used to examine the relations among measures of pain catastrophizing, pain severity, depressive symptoms, and PTSS at baseline. Paired samples T-tests were used to examine the treatment-related changes from baseline to post-treatment for pain catastrophizing, pain severity, depressive symptoms, and PTSS.

The cross-lagged panel analysis was conducted using the lavaan package in R (3.5.2) to examine the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and PTSS across all three study test-points. Cross-lagged panel analyses allow for the estimation of the directional influence between variables over time by controlling for autoregressive and synchronous effects (Kearney, 2017; Selig & Little, 2012). On the basis of previous research, age, gender and pain duration were tested as potential covariates for the cross-lagged panel analysis (Feinstein et al., 2017; Keefe et al., 2000; Son et al., 2019; Yarnitsky et al., 2008; Zhaoyang et al., 2020). In the present sample, only gender was significantly associated with pain catastrophizing and therefore included as a covariate in the model.

Cross-lagged panels models must first be assessed for how well a model fits the data. The following fit indices were considered: the model chi-square, Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and (Standardized) Root Mean Square Residual (SRMR). Although there are no universally accepted

strategies for determining the adequacy of model fit, the following criteria have been recommended: a non-significant chi square, relative goodness-of-fit indices (CFI, TLI) > 0.90, and absolute goodness-of-fit indices (RMSEA, SRMR) <0.08 (Kearney, 2017). Modification indices are used to improve model fit if some model fit indices fall outside of the recommended thresholds. Once a model is determined to have adequate fit based on the model fit indices, the paths of the model are reviewed to determine their significance and strength using beta coefficients, standard errors, and p-values.

Results

Descriptive characteristics

Demographic information for the sample at admission are presented in **Table 1**. The mean age of the sample was 36 years (SD = 9.69 years), and the mean duration of pain at the time of enrolment was 13 weeks (SD = 8.48). The majority of participants had completed high school (82.5%). Women represented 68.0% of the recruited sample (n = 264). Women and men differed significantly in their occupation (χ^2 [6] = 99.34, $p < 0.001$) and level of education (χ^2 [4] = 40.74, $p < 0.001$). Men also had more elevated levels of pain catastrophizing compared to women at baseline (t[267.04] = -2.14, $p = 0.033$). No other significant gender differences were found in any sample characteristics. The remainder of the analyses were conducted on the entire sample without stratifying based on gender.

Treatment-related changes in study variables

Paired samples T-tests (pre-treatment to post-treatment) were used to examine the treatment-related changes on variables used in the cross-lagged panel analysis (see **Table 2**). Mean scores at admission for pain catastrophizing, depression, and PTSS were comparable (within 1 standard deviation) to those reported in previous research on individuals with whiplash

injuries (Bostick et al., 2013; Bunzli et al., 2019; Sullivan, Davidson, et al., 2009). The present study sample can be characterized as experiencing moderate levels of pain (Boonstra et al., 2016), pain catastrophizing (Wheeler et al., 2019), depressive symptoms (Erford et al., 2016), and PTSS (Creamer et al., 2003) at treatment admission.

Results of the paired samples t-tests revealed that measures of pain catastrophizing, pain severity, depression, and PTSS showed significant reductions over the course of treatment. Large effect sizes were found for reductions in pain catastrophizing, pain severity, and PTSS; the reduction in depressive symptoms over the course of treatment was of a medium effect size. The magnitude of these reductions is comparable to similar studies conducted with individuals with whiplash injuries participating in standardized multidisciplinary treatment programs (Angst et al., 2010; Angst et al., 2014; Sullivan, Adams, et al., 2006; Sullivan, Thibault, et al., 2009).

Associations among study variables

Table 3 presents the correlations among the variables used in the cross-lagged panel analysis. Our findings are consistent with previous research, showing significant correlations between scores on the PCS and scores on measures of pain severity, depressive symptoms, and PTSS (Linton et al., 2011; Sullivan, Thibault, et al., 2009; Sullivan, Thorn, et al., 2001; Thompson et al., 2010). Also consistent with previous research, scores of pain severity were significantly correlated with levels of depressive symptoms and PTSS (Lopez et al., 2013; Sullivan et al., 2016).

Cross-lagged panel analysis

Figure 1 presents the proposed theoretical model that was initially tested. One index of relative goodness of fit (CFI = 0.968) and one index of absolute goodness of fit (SRMR = 0.024) were within acceptable ranges. However, another index of relative goodness of fit (TLI = 0.897)

as well as another index of absolute goodness of fit (RMSEA = 0.106) were not within acceptable ranges. In addition, the χ^2 was statistically significant (χ^2 = 129.62, df = 24, p < 0.001); these fit indices suggested the presence of some model misspecification.

To improve model fit, modification indices were used to assess whether any important relations were missing from the model. Level 2 autoregressive relations (i.e., relations between the same construct at admission and end of treatment) for PTSS were added based on modification indices. Given that the model using modification indices was nested within the original theoretical model, they were compared using a Likelihood Ratio Test. The level 2 autoregressive relations were found to significantly improve model fit (χ^2 [1] = 47.66, p < 0.001), providing the modified model with overall adequate fit (CFI = 0.982; TLI = 0.940; RMSEA = 0.081; SRMR = 0.022; χ^2 = 81.96, df = 23, p < 0.001) and suggesting good representation of the data. As such, the final model is presented in **Figure 2**. All reported beta coefficients are standardized.

The final model revealed that pain catastrophizing scores at T1 predicted depressive symptoms (β = 0.161, SE = 0.037, p < .001), PTSS (β = 0.171, SE = 0.089, p < .001), and pain severity (β = 0.202, SE = 0.009, p < .001) at T2. Pain catastrophizing scores at T2 also predicted all three variables at T3: depressive symptoms (β = 0.175, SE = 0.033, p < .001), PTSS (β = 0.212, SE = 0.064, p < .001), and pain severity (β = 0.217, SE = 0.008, p < .001). Depressive symptoms and PTSS at T2 were significant predictors of pain severity at T3 (β = 0.135, SE = 0.011, p = .005 and β = -0.142, SE = 0.004, p = .004, respectively). PTSS was a significant predictor of pain catastrophizing scores from T1 to T2 (β = 0.126, SE = 0.024, p = .010) as well as from T2 to T3 (β = 0.160, SE = 0.020, p < .001). Depressive symptoms as well as pain severity at T2 also predicted level of pain catastrophizing at T3 (β = 0.115, SE = 0.047, p = .003

and β = 0.120, SE = 0.205, p < .001, respectively). In addition to pain catastrophizing, depressive symptoms were also a significant predictor of PTSS, from T1 to T2 (β = 0.163, SE = 0.098, p < .001) as well as from T2 to T3 (β = 0.100, SE = 0.081, p = .005). Pain severity only significantly predicted pain catastrophizing, from T2 to T3 (β = 0.120, SE = 0.205, p < .001).

Discussion

The present study aimed to examine the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and PTSS in individuals receiving treatment for a whiplash injury. The findings of the present study are consistent with previous research showing significant associations between pain catastrophizing and pain severity (Birch et al., 2019; Edwards et al., 2016; Gilliam et al., 2019; Sullivan, Thorn, et al., 2001), depressive symptoms (Burns et al., 2003; Geisser et al., 1994; Gilliam et al., 2017; Hulsebusch et al., 2016), and PTSS (Ciccone & Kline, 2012; Giummarra et al., 2017; Ravn et al., 2019). Our findings extend those of previous research by showing that, through the course of a multidisciplinary rehabilitation intervention, earlier levels of pain catastrophizing predicted later levels of pain severity, depression, and PTSS. The results also supported bidirectional relations between pain catastrophizing, pain, depression, and PTSS, particularly in the later stages of treatment. To our knowledge, this is the first study using cross-lagged panel analyses to support an antecedent or causal role of pain catastrophizing in the prediction of pain severity, depression, and PTSS in individuals undergoing treatment for whiplash injury.

One of the most consistent findings on outcomes following a whiplash injury has been that high scores on measures of pain catastrophizing are associated with more severe pain (Ritchie & Sterling, 2016; Sarrami et al., 2017; Sterling, 2011; Walton et al., 2013). In the current study, results showed that pain catastrophizing, assessed at the time of admission (T1),

predicted pain severity, depression, and PTSS at mid-treatment assessment (T2). Pain catastrophizing at T2 also predicted pain severity, depression, and PTSS at treatment termination (T3). There was also evidence of bidirectional relations, particularly in the later stages of treatment, where pain severity, depressive symptoms, and PTSS at T2 predicted pain catastrophizing at T3. PTSS at T1 also predicted pain catastrophizing at T2.

Very few studies have explored the direction of influence in the relations between pain catastrophizing and pain severity, depressive symptoms, and PTSS in individuals with whiplash injuries. Beierl et al. (2020) examined the sequential relations between negative appraisals and PTSS in individuals admitted to hospital following a motor vehicle collision or assault. Path analytic procedures revealed that negative appraisals assessed 1-month post-trauma predicted the persistence of PTSD 6 months following the event (Beierl et al., 2020). Given that pain catastrophizing can be construed as a form of negative appraisal, the results of the Beierl et al. (2020) study can be considered consistent with the findings of the present study. Similarly, Liew et al. (2019) used Bayesian Network analyses to examine the sequential relations among several pain-related psychosocial variables, including pain catastrophizing, in individuals with chronic whiplash symptoms participating in a physical therapy intervention (Liew et al., 2019). Measures of pain and pain catastrophizing were completed at 4 timepoints over a 12-month period. The results of their analyses showed that changes in pain catastrophizing predicted subsequent changes in pain, mediated by changes in self-efficacy. Self-efficacy was not assessed in the present study and, as such, the mediating role of self-efficacy could not be assessed. To our knowledge, there are no previous studies examining the direction of influence in the relations between pain catastrophizing and depressive symptoms as well as PTSS in individuals with whiplash injuries.

The findings of the current study are comparable to studies using cross-lagged panel models to examine temporal relations between pain catastrophizing and clinical outcome measures in other populations. Sequential relations between pain catastrophizing and pain severity have been reported in individuals with neuropathic pain (Racine et al., 2016) and chronic pain (Burns et al., 2021). There is also support for the sequential relation between pain catastrophizing and PTSS in individuals who had experienced a work-disabling traumatic event (Donayre Pimentel et al., 2020). Studies examining the prospective relation between measures related to catastrophizing, such as cognitive coping, negative appraisals, or dysfunctional beliefs (Beck et al., 1979; Moore et al., 2018), and depressive symptoms have reported findings comparable to those of the current study (DeRubeis et al., 1991; Garnefski & Kraaij, 2007).

Gellatly and Beck (2016) recently have proposed that catastrophizing might be a determinant of the onset and maintenance of symptoms of a wide range of health and mental health problems. They argue that catastrophizing might be a transdiagnostic maladaptive process, with unique beliefs specific to different physical and psychological conditions (Gellatly & Beck, 2016). Gellatly and Beck (2016) suggest that, although the specific content of catastrophic thinking might vary across different health and mental health conditions, cognitive processes triggered by catastrophizing such as interpretive bias, attentional bias, and attentional fixation might act as vulnerability factors common to a wide range of health and mental health conditions (Gellatly & Beck, 2016). To our knowledge, the present study is the first to provide support for the transdiagnostic role of pain catastrophizing as a determinant of the persistence of symptoms of pain, depression, and PTSD following whiplash injury.

Although cognitive models propose the casual or antecedent role of cognitive variables such as catastrophic thinking on mental health outcomes (Beck et al., 1979; Ellis, 1962; Gellatly

& Beck, 2016), these models do not specify the time-frame over which these associations can be expected to emerge. The findings of the current study demonstrated that pain catastrophizing can influence levels of pain severity, depressive symptoms, and PTSS during the first two months of rehabilitation treatment for whiplash injury. These findings corroborate the time-dependent relationship between catastrophizing and pain severity found in previous research in pain populations (Beierl et al., 2020; Burns et al., 2021; Liew et al., 2019; Racine et al., 2016). Longer intervals of assessment, such as 12 weeks, have been more common in previous research on the time-dependent relationship between catastrophizing and pain severity (Campbell et al., 2012; Racine et al., 2016; Roman et al., 2021; Speed et al., 2021). However, some research suggests that the window of influence of catastrophizing on pain severity might be as short as one week in chronic pain populations, or even 30 minutes in experimental manipulations (Burns et al., 2021; Campbell et al., 2012). Our findings showed that pain catastrophizing had the strongest influence on all other variables during the first four weeks of treatment, which replicates the results of previous studies. Research on the impact of catastrophizing on symptoms of mental health problems such as depressive symptoms and PTSS have revealed a similar time-frame of influence, spanning over weeks or months (DeRubeis et al., 1991; Donayre Pimentel et al., 2020; Garnefski & Kraaij, 2007). The use of observational data, as in the current study, to demonstrate that pain catastrophizing precedes and predicts problematic recovery outcomes is warranted prior to using experimental designs, such as RCTs, to support the causal role of pain catastrophizing (Baribeau et al., 2022). Better understanding of the time-dependent relationship between catastrophizing and recovery outcomes will facilitate the translation of these findings to a clinical context.

There are important clinical implications to the findings of the present study. The risk of developing chronic pain following whiplash injury is high, with up to 50% of individuals with whiplash injury remaining symptomatic one year after injury (Sterling, 2016). Improvements in the treatment of whiplash injury over the past three decades have been minimal, and unsuccessful in reducing the proportion of individuals who transition from acute to chronic pain (Jull et al., 2011). Results from the current study support the importance of using scores on measures of pain catastrophizing to identify individuals with heightened risk of experiencing high levels of pain severity, depressive symptoms, and PTSS following a whiplash injury.

A recent systematic review and meta-analysis concluded that interventions used to reduce pain catastrophizing have yielded only modest outcomes, with reductions in pain catastrophizing often being too small to be considered clinically significant (Schutze et al., 2018). Treatment-related reductions in pain catastrophizing might be minimal due to the presence of un- or undertreated mental health difficulties, such as depression and PTSD (Paré et al., 2019). Given the consistency with which pain catastrophizing has been linked to problematic recovery outcomes, the development of interventions capable of yielding clinically meaningful reductions in pain catastrophizing would appear to be a priority.

There are limitations to the interpretation of these findings. First, the sample was recruited from a network of multidisciplinary rehabilitation clinic following a whiplash injury. Not all individuals who have sustained whiplash injuries receive treatment through multidisciplinary rehabilitation clinics; many simply receive guidance and follow-up with a physician (Cote et al., 2001). It is possible that only more complex cases are referred to a rehabilitation clinic and, as such, may not be representative of all individuals suffering from subacute whiplash injuries. In addition, the average duration of whiplash-related pain for study

participants was 14 weeks and all participants in the study sample were absent from work at the time of recruitment. These sample characteristics have implications for the generalizability of the study findings.

It is also important to consider that, although the statistical model used for this study (i.e., cross-lagged panel analysis) was appropriate for the research question, the results should be interpreted as supporting the 'potential' causal influence of pain catastrophizing on pain severity, depressive symptoms, and PTSS. The results of cross-lagged analyses do not prove causality (Antonakis et al., 2010; Fedak et al., 2015; Kenny, 1975). The correlational design of the study, albeit longitudinal, precludes drawing strong conclusions about causality. The results of the cross-lagged panel analyses support the temporal precedence of pain catastrophizing in relation to symptoms of pain, depression, and PTSD, and might best be construed as reflecting the direction of influence of pain catastrophizing as opposed to the causal role of pain catastrophizing. It has been noted that an assumption that is rarely met in cross-lagged panel analyses is that all relevant variables have been measured and included in the model being tested (Kearney, 2017). It is not possible to rule out the possibility that an omitted variable, perhaps one strongly associated with pain catastrophizing, is actually the causal variable.

Despite these limitations, the strengths of this study in terms of study design and statistical approach are consistent with theoretical positions that propose a transdiagnostic influence of catastrophic thinking. To our knowledge, this is the first study to examine the temporal relations between pain catastrophizing, pain severity, depressive symptoms, and PTSS in individuals with whiplash injuries using a cross-lagged panel analysis. These findings have important implications for the treatment of individuals with whiplash injuries and might guide

the improvement of treatments aimed at reducing levels of pain catastrophizing, thereby improving on pain-related outcomes.

Acknowledgements

This research was supported by funds from the *Institut de recherche Robert-Sauvé en santé et en sécurité du travail* (IRSST) and the Canada Research Chairs (CRC) Program.

Tables and Figures

Table 1. Baseline sample characteristics overall and stratified by gender.				
Characteristics	**Overall (n = 388)**	**Women (n = 264)**	**Men (n = 124)**	***p***
Age, mean (SD)	36 (9.69)	36 (9.83)	35 (9.40)	n.s.
Marital status, n (%)				<.01
Single	129 (33%)	76 (29%)	53 (43%)	
Common law	107 (28%)	75 (29%)	32 (26%)	
Married	84 (22%)	60 (23%)	24 (20%)	
Separated/divorced	60 (16%)	49 (19%)	11 (9%)	
Widowed	3 (1%)	0 (0%)	3 (2%)	
Education, n (%)				<.01
Less than high school	68 (18%)	35 (13%)	33 (27%)	
High school	110 (28%)	62 (24%)	48 (39%)	
Trade school	66 (17%)	43 (16%)	23 (18%)	
College	93 (24%)	85 (32%)	8 (6%)	
University	51 (13%)	39 (15%)	12 (10%)	
Occupation, n (%)				<.01
Laborer	115 (30%)	57 (22%)	58 (47%)	
Driver	19 (5%)	3 (1%)	16 (13%)	
Nursing	98 (25%)	98 (37%)	0 (0%)	

Trade	52 (13%)	34 (13%)	18 (15%)	
Sales	21 (5%)	11 (4%)	10 (8%)	
Administrative	80 (21%)	61 (23%)	19 (15%)	
Student	3 (1%)	0 (0%)	3 (2%)	
Pain duration (weeks), mean (SD)	13.89 (8.48)	13.98 (8.66)	13.71 (8.11)	n.s.
Number of pain sites, mean (SD)	2.82 (0.79)	2.82 (0.79)	2.82 (0.80)	n.s.
Medication, n (%)				n.s.
None	38 (10%)	22 (8%)	16 (13%)	
NSAIDS/OTC	164 (42%)	121 (46%)	43 (35%)	
Narcotic	69 (18%)	54 (20%)	15 (12%)	
Anti-inflammatory	19 (5%)	12 (5%)	7 (5%)	
No response	98 (25%)	55 (21%)	43 (35%)	
PCS, mean (SD)	22.20 (10.27)	21.47 (10.58)	23.76 (9.45)	.03
Pain NRS, mean (SD)	5.17 (1.80)	5.23 (1.66)	5.03 (2.07)	n.s.
BDI-II, mean (SD)	15.05 (9.32)	15.26 (8.44)	14.60 (10.96)	n.s.
IES-R, mean (SD)	33.23 (22.39)	33.97 (22.41)	31.66 (22.36)	n.s.

Note: SD = standard deviation. NSAIDS = non-steroidal anti-inflammatory drug, OTC = over-the-counter. Pain sites are neck, back, upper limbs, and lower limbs.

Table 2. Treatment-related changes in cross-lagged panel analysis variables.					
	Pre-treatment Mean (SD)	**Mid-treatment Mean (SD)**	**Post-treatment Mean (SD)**	***p***	**Cohen's d**
PCS	22.20 (10.27)	16.52 (10.86)	12.57 (10.50)	.001	1.06
NRS	5.17 (1.80)	4.78 (1.69)	3.88 (1.91)	.001	0.63
BDI	15.05 (9.32)	12.72 (8.63)	11.07 (8.89)	.001	0.49
IES	33.23 (22.39)	26.90 (20.82)	22.55 (19.53)	.001	0.70

Note: N = 388. PCS = Pain Catastrophizing Scale; range is 0-52. NRS = Numerical Rating Scale for pain severity; range is 0-10. BDI-II = Beck Depression Inventory – II; range is 0-63. IES-R = Impact of Events Scale – Revised; range is 0-88. P-values are based on a comparison of pre-treatment and post-treatment means.

* $p < .05$; ** $p < .01$

Table 3. Correlations between pain and psychological measures at pre-treatment.						
	1.	**2.**	**3.**	**4.**	**5.**	**6.**
1. Age	-					
2. Pain duration (weeks)	-.03	-				
3. PCS	.04	.02	-			
4. Pain NRS	-.01	.01	.23**	-		
5. BDI-II	-.08	.02	.48**	.25**	-	
6. IES-R	-.02	.03	.64**	.25**	.63**	-

Note: N = 388. PCS = Pain Catastrophizing Scale. NRS = Numerical Rating Scale. BDI-II = Beck Depression Inventory – II. IES-R = Impact of Events Scale – Revised.

* $p < .05$; ** $p < .01$

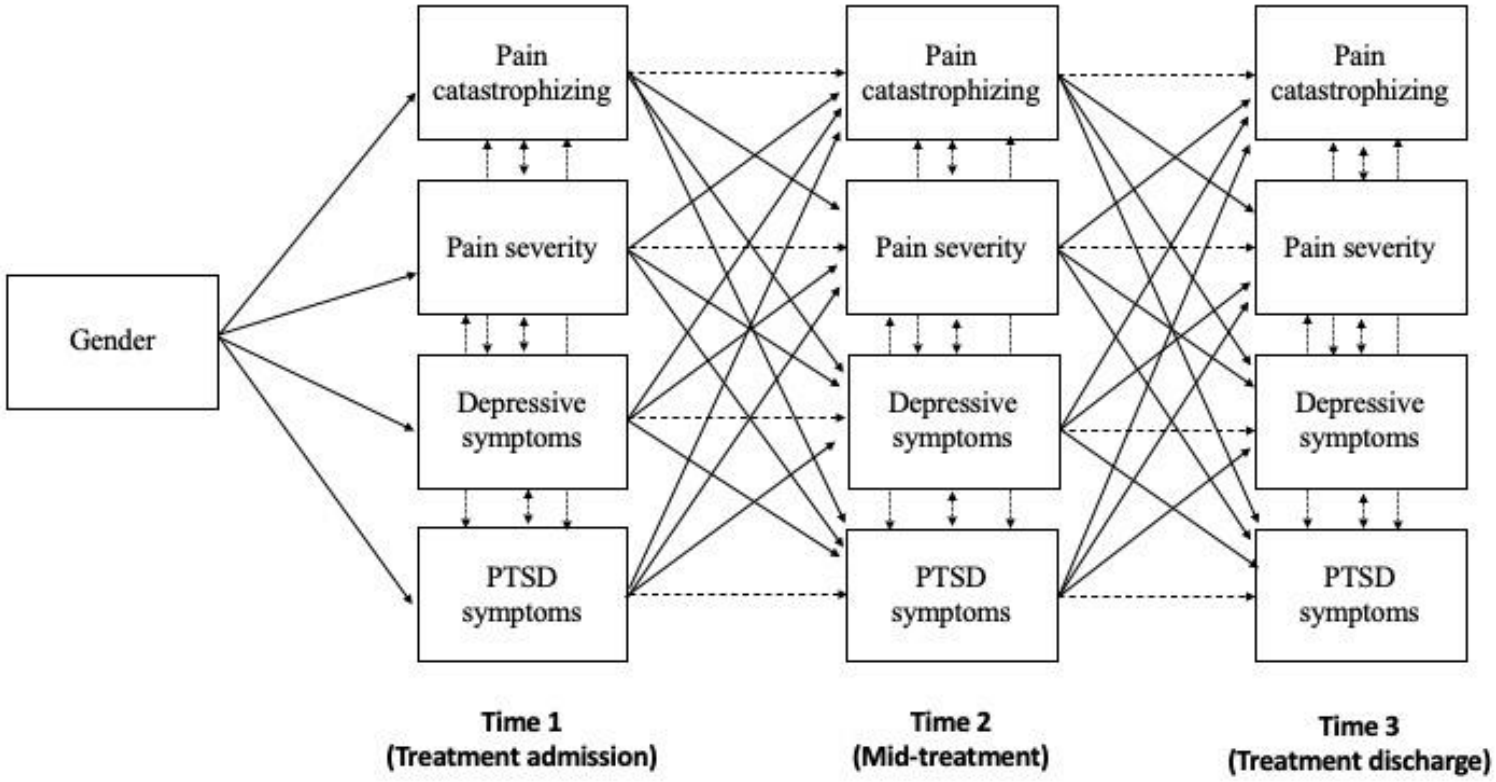

Figure 1. Theoretical path model. Covariates were assessed at treatment admission. Pain catastrophizing, pain severity, PTSD symptoms, and depressive symptoms were each assessed at treatment admission, mid-treatment (4 weeks post-admission), and post-treatment (7 weeks post-admission). Continuous lines show regression paths. Dotted lines show synchronous correlations. Dashed lines show autoregressive relations.

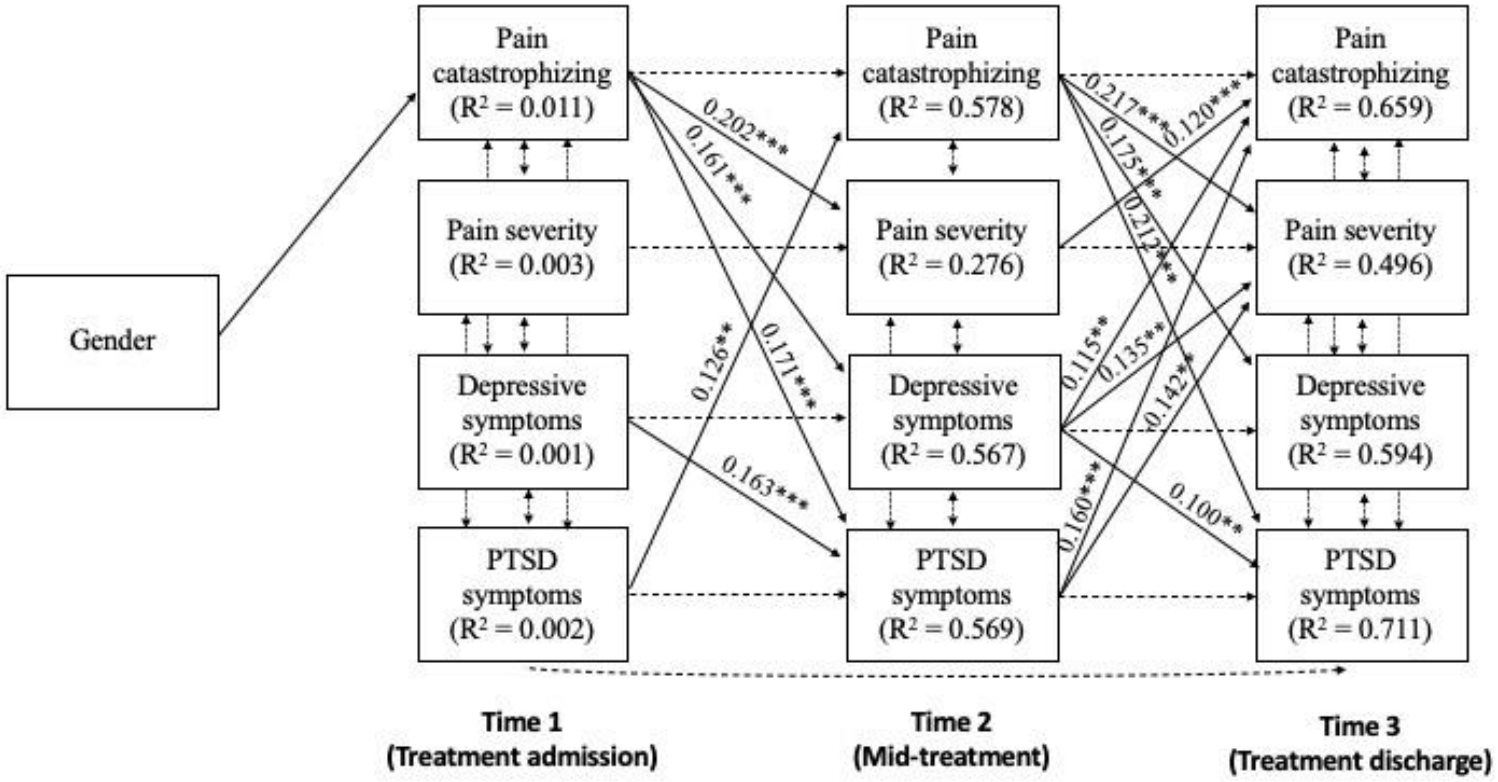

Figure 2. Final path model, extended by including level 2 autoregressive relations for PTSS.
Covariate was assessed at treatment admission. Pain catastrophizing, pain severity, PTSS and depressive symptoms were each assessed at treatment admission (T1), mid-treatment (T2; 4 weeks post-admission), and post-treatment (T3; 7 weeks post-admission). For visual parsimony, only significant paths are shown and only standardized regression coefficients are indicated. Continuous lines show standardized regression paths. Dotted lines show synchronous correlations. Dashed lines show autoregressive correlations. R^2 = percentage of explained variance
***** / ** / * = p < 0.001 / <0.01 / <0.05.**

Chapter 4: General Discussion

Whiplash injury is associated with the highest costs of all injuries incurred in motor vehicle collisions (Cassidy et al., 2000; Pink et al., 2016; Quinlan et al., 2004). Pain catastrophizing has emerged as one of the most robust psychological predictors of problematic recovery following whiplash injury (Sarrami et al., 2017; Sullivan et al., 2011). The current thesis sought to better understand the processes by which pain catastrophizing impacts problematic recovery outcomes following whiplash injury.

The central objective of this thesis research was to examine the pathways through which pain catastrophizing negatively impacts recovery outcomes. Several decades of research have identified high levels of mental health comorbidity in musculoskeletal conditions (Bair et al., 2003; de Heer et al., 2018; IsHak et al., 2018; Moeller-Bertram et al., 2012; Ravn et al., 2018; Sharp & Harvey, 2001). Pain catastrophizing is a factor which has been found to impact on mental health conditions as well as pain-related outcomes in whiplash-injured populations (Bostick et al., 2013; Carty et al., 2011; Nieto et al., 2011; Vangronsveld et al., 2009). It has been suggested that pain catastrophizing might be a key factor in contributing to high rates of comorbidity between pain and mental health conditions (Gellatly & Beck, 2016; Gilliam et al., 2019; Linton & Bergbom, 2011).

Two studies were conducted to test the hypothesis that pain catastrophizing impacts on recovery outcomes following whiplash injury by increasing the risk of experiencing debilitating mental health symptoms such as depression and post-traumatic stress disorder (PTSD). The purpose of Study 1 was to examine the relation between pain catastrophizing and clinically significant symptoms of depression and PTSD in individuals who had recently sustained a whiplash injury. A ‘mental health comorbidity’ variable was created to reflect the high rates of

comorbidity between depression and PTSD in the literature (Gilliam et al., 2019; Hefner & Rosenheck, 2019; Shih et al., 2010) as well as in the dataset. Study 1 also addressed whether the severity of symptoms of depression and PTSD were a pathway impacting the relation between pain catastrophizing and occupational disability 1 year after a whiplash injury. Study 2 examined the direction of influence between pain catastrophizing and symptoms of mental health problems as well as pain severity in individuals receiving treatment for whiplash injuries.

In the following sections, a brief summary of the findings of the two studies and their context within related research will be presented. Given that the two manuscripts included in the present thesis already offer a detailed interpretation of our findings based on previous work in the area, the general discussion will emphasize the overall contribution of our findings to the existing literature. The theoretical and clinical implications of these findings will be discussed.

Summary of findings

Whiplash injuries remain a debilitating condition with significant costs to individuals, their communities, the healthcare system, and more. Better understanding the processes through which pain catastrophizing contributes to disability following whiplash injury is an important step in improving recovery outcomes from both a research and clinical perspective. The findings of the current studies build upon the widely accepted notion that pain catastrophizing is one of the most robust predictors of recovery outcomes following whiplash injury.

The two studies in the current thesis extend previous research in a number of ways. First, results from Study 1 demonstrate that scores on a measure of pain catastrophizing can differentiate between participants with and without mental health comorbidity. Our findings also reveal that the relation between pain catastrophizing and occupational disability is influenced by the presence of mental health comorbidity (Study 1). The pattern of findings remained

unchanged even when using a more stringent cut-score for depressive symptoms, as suggested for use in pain research (Geisser et al., 1997). Results of Study 2 provide support for the antecedent role of pain catastrophizing in the prediction of pain severity, depression, and PTSS in individuals undergoing treatment for whiplash injury. Taken together, the findings of this thesis suggest that the interplay between pain and mental health variables is crucial to consider in the context of rehabilitation following whiplash injury, and that pain catastrophizing appears to have a transdiagnostic role in the onset and maintenance of health and mental health problems in this context.

Theoretical implications

The findings of Studies 1 and 2 provide evidence for the potential role of pain catastrophizing as a transdiagnostic variable for pain-related and mental health outcomes. A transdiagnostic approach "identif[ies] similarities in comorbidities" (Linton & Bergbom, 2011, p. 51) in order to uncover shared mechanisms (i.e., factors which impact multiple conditions simultaneously). In the context of pain, a transdiagnostic approach suggests that there are shared mechanisms between the persistence of pain and comorbid conditions, such as mental health difficulties, which negatively impact functioning and well-being (Linton et al., 2018). Transdiagnostic models endeavour to provide a more parsimonious explanation for the comorbidities of pain conditions (Mansell et al., 2009). Targeting these shared mechanisms, or transdiagnostic variables, rather than treating each individual condition separately is likely a more efficacious manner of reducing the burden of living with a pain condition.

Although the importance of catastrophizing as a risk factor has been acknowledged for several decades (Quartana et al., 2009; Sullivan, Thorn, et al., 2001; Turner & Aaron, 2001), the potential transdiagnostic influence of pain catastrophizing was first addressed by Linton and

Bergbom in 2011. These researchers highlighted the similar role of catastrophic thinking in traditional cognitive models of depression (Beck et al., 1979) and in the fear-avoidance model of musculoskeletal pain conditions (Vlaeyen & Linton, 2000). They suggested that these conceptual models, in addition to the empirical findings linking catastrophizing to depressive symptoms and to pain severity, provided evidence for the key role of catastrophizing in explaining the comorbidity between pain and depression (Linton & Bergbom, 2011).

Gellatly and Beck (2016) later addressed how catastrophic thinking had been invoked as an explanatory construct for several mental health and health conditions, such as pain, phobias, obsessive-compulsive disorder, traumatic brain injuries, and PTSD. These authors suggested that cognitive and emotional processes associated with catastrophizing are largely consistent across a range of health and mental health conditions, while the content of catastrophizing and subsequent beliefs are distinct for each condition (Gellatly & Beck, 2016). Although the current thesis advances empirical evidence for the transdiagnostic role of pain catastrophizing in predicting pain severity, depressive symptoms, and PTSS following whiplash injury, further research is needed to confirm these findings with diagnosed mental health conditions such as Major Depressive Disorder and PTSD.

Gellatly and Beck (2016) propose a model to describe the mechanisms through which catastrophic thinking impacts on health and mental health conditions. They suggest that catastrophic thinking triggers cognitive processes such as interpretive bias, attentional bias, and attentional fixation, which might act as common vulnerability factors for different health and mental health conditions (Gellatly & Beck, 2016). Indeed, pain catastrophizing has been shown to be associated with interpretive bias (Elhamiasl et al., 2020; Heathcote et al., 2016; Khatibi et al., 2014), attentional bias (Crombez et al., 1998; Jones et al., 2021; Michael & Burns, 2004;

Spanos et al., 1979), and attentional fixation (Heathcote et al., 2015; Van Damme et al., 2002; Vervoort et al., 2013). For example, when shown ambiguous facial expressions, healthy individuals reporting higher levels of pain catastrophizing were quicker to respond to stimuli related to painful expressions than stimuli related to happy expressions (Khatibi et al., 2014). Elhamiasl et al. (2020) used self-report measures of interpretative bias and catastrophizing as an emotional regulation tool in a sample of 30 individuals with Illness Anxiety Disorder and 30 healthy controls matched on gender and age. Results revealed a significant correlation between interpretation bias and catastrophic thinking (Elhamiasl et al., 2020). Heathcote et al. (2016) found that, in a community sample of adolescents aged 16 or older, the tendency to negatively interpret different types of ambiguous stimuli (i.e., related to pain, health, and social contexts) was positively correlated with catastrophizing scores. In addition, the latter study found evidence for a mediation model, wherein interpretative bias completely mediated the relationship between catastrophic thinking and recent pain experiences (Heathcote et al., 2016).

The inability to shift attention away from pain, or attentional bias to pain, is an important aspect of our understanding of the possible mechanisms through which pain catastrophizing impacts the experience of pain (Spanos et al., 1979). A recent meta-analysis of eye-tracking studies found that a small but significant amount of variance in first fixation – the tendency to initially look at a pain-related stimulus before a non-pain-related stimulus – was accounted for by pain catastrophizing (Jones et al., 2021). Using a reaction-time paradigm, Crombez et al. (1998) showed that participants who reported scores above the median on the Pain Catastrophizing Scale (PCS) responded significantly more slowly to an auditory stimulus when it was immediately preceded by a painful electrocutaneous stimulus compared to a control electrocutaneous stimulus (Crombez et al., 1998). Michael and Burns (2004) used an attentional

paradigm on a sample of 82 chronic pain participants during the cold pressor task to explore the impact of catastrophizing levels on pain severity. Participants were divided into three conditions: sensory focus (i.e., attending to physical aspects of the pain experience, such as burning), affect focus, (i.e., attending to emotional aspects of the pain experience, such as excruciating) or control. Results showed that participants with higher levels of pain catastrophizing in the affect focus condition were associated with a reduced threshold and tolerance during the cold pressor task, whereas this association was not seen in participants with lower levels of pain catastrophizing (Michael & Burns, 2004). These findings suggest that higher levels of catastrophic thinking create an attentional bias towards threatening and distressing aspects of pain.

Catastrophic thinking has also been both theoretically and empirically associated with attentional fixation. The 'rumination' factor of the PCS has been conceptualized as the tendency to continue attending to pain stimuli or the inability to disengage from pain-related stimuli (Sullivan et al., 1995). Empirical evidence suggests that higher levels of pain catastrophizing might reduce the ability to disengage from pain-related stimuli (Van Damme et al., 2002). In one study, healthy adolescents completed a dot-probe task, in which participants were required to respond as quickly and as accurately as possible regarding the position of a dot on the screen following the presentation of a stimulus. Participants with higher levels of pain catastrophizing were found to have a significant association between low levels of attentional control (i.e., the inability to flexibly shift attention, or avoid attentional fixation) and increased attentional vigilance (Heathcote et al., 2015). Using an eye-tracking task, Vervoort and colleagues (2013) conducted a study on healthy participants to explore how attentional processes related to painful facial expressions are related to pain catastrophizing. Participants who reported high levels of

pain intensity over the previous three months had a significantly longer overall gaze for all facial expressions (i.e., neutral and painful) when they also reported higher levels of pain catastrophizing, in comparison to participants reporting lower levels of pain catastrophizing (Vervoort et al., 2013).

Beyond the identification of treatment mechanisms, an important question to consider in the interpretation of the findings of this thesis as well as other literature on treatment mechanisms for addressing pain and comorbid mental health conditions relates to the timing of intervention and measurement (Laurenceau et al., 2007). Research on these topics is incredibly heterogenous in the assessment of when change might take place. In fact, most studies minimally or do not acknowledge the timing of their measurements when comparing to other similar studies. This is especially relevant when using statistical approaches such as cross-lagged panel models, which depend on the assumption of timing: that variables included within the model have been assessed simultaneously at different time points, that these timepoints are equidistant from one another, and that these timepoints are appropriate for the expected changes. If research on interventions targeting important risk factors are not sensitive to the "developmental timeline" of chronic pain (Linton et al., 2018, p. 321), important findings might be missed entirely. Little research has been conducted to guide researchers in navigating this critical question. Other researchers have previously highlighted that "change does not necessarily occur in a linear, steady way" (Thorn & Burns, 2011, p. 706), meaning that it would be faulty to assume that findings will remain consistent regardless of when change is assessed. Indeed, these questions have a direct impact on findings related to mediation and moderation of treatment outcomes (Laurenceau et al., 2007).

Clinical implications

The findings of the current thesis also provide meaningful empirical evidence for the relevance and utility of pain catastrophizing in a clinical context following whiplash injury. Study 1 of this thesis demonstrated the clinical utility of the PCS for identifying the presence of clinically significant mental health comorbidities (i.e., depression and/or PTSD). In addition, findings from Study 1 showed that the presence of clinically significant levels of depression and/or PTSD prior to treatment significantly predicted occupational disability at a one-year follow-up. Building upon these findings, Study 2 demonstrated that pain catastrophizing might play a transdiagnostic role in influencing pain severity, depressive symptoms, and PTSS, particularly earlier in treatment.

In the initial stages following a whiplash injury (i.e., the acute and subacute stages), individuals primarily consult with primary care professionals, such as family doctors and physiotherapists, to treat their symptoms. Current clinical recommendations for neck pain highlight the importance of identifying and modifying prognostic risk factors such as psychological factors to reduce the likelihood of prolonged impairment (Cote et al., 2016). Nonetheless, up to 50% of individuals with whiplash injuries have not recovered one year following their injury (Carroll et al., 2008; Sterling, 2016). This suggests that assessment of prognostic risk factors at the primary care level remains inadequate for preventing prolonged recovery following whiplash injury. Our findings point to the impediment that comorbid mental health conditions can have on recovery from whiplash injury. As such, identification and subsequent treatment of these comorbidities is likely an important aspect of optimizing treatment for whiplash injury.

As demonstrated in Study 1, the PCS could be used in primary care contexts to effectively identify individuals with clinically significant levels of mental health comorbidity. Primary care professionals working with acute whiplash injuries could screen patients for referral to mental health services. Unfortunately, existing research suggests that the PCS is currently underutilized in primary care to identify high-risk pain patients. One study found that only 15.1% of physiotherapists in Spain routinely use the PCS (Otero-Ketterer et al., 2023). In a study of primary care physicians and physiotherapists in Saudi Arabia, the PCS was used on average by <5% of study participants (Alhowimel et al., 2021). This is an important contrast to the high rates of use of the PCS in tertiary care, where the challenges associated with prolonged pain and comorbid mental health problems have already emerged. Administration of the PCS in primary care settings would permit for the identification of high-risk pain patients and subsequent treatment of risk factors such as pain catastrophizing and mental health conditions, potentially preventing the chronification of pain. To address this implementation gap, routine screening of pain catastrophizing could be incorporated in the structure of health care services, similarly to how health history information is collected. Several shortened versions of the PCS have been developed (Cheng et al., 2019; McWilliams et al., 2015; Walton et al., 2020) and could be included as part of standardized intake assessments in primary care settings.

As such, utilizing pain catastrophizing levels to identify patients who would benefit from additional services (i.e., mental health support) appears to be a crucial first step in the implementation of risk-targeted interventions. Once problematic levels of pain catastrophizing have been identified, risk-targeted interventions can be used specifically to reduce levels of pain catastrophizing. The findings of the current thesis suggest that, by targeting pain catastrophizing levels, treatment could subsequently reduce pain severity as well as mental health symptoms.

Although research on the role of pain catastrophizing as a risk factor for problematic recovery outcomes in individuals with whiplash injuries supports pain catastrophizing as an important treatment target, little to no research exists regarding clinical interventions targeting pain catastrophizing as a transdiagnostic variable. Adopting a transdiagnostic perspective could help improve assessment and treatment of pain conditions such as whiplash injury by focusing on shared mechanisms rather than treating comorbid conditions separately. Treatments targeting transdiagnostic processes have the potential to improve the effectiveness of multidisciplinary pain treatment as well as reduce the presence of comorbid conditions (Linton et al., 2018).

Although the exploration of a transdiagnostic approach for pain treatment is relatively new, many schools of psychotherapy have been moving towards transdiagnostic treatment for several decades. Many mental health conditions, such as anxiety and depression, are argued to have similar symptoms or common elements (Barlow et al., 2004). Similar to pain researchers (Linton, 2013; Linton et al., 2018), researchers in the domain of mental health acknowledge that addressing the underlying processes of comorbid mental health conditions can be more efficient than treating the symptoms of multiple specific conditions (Farinha-Fernandes et al., 2020; Gallagher, 2017). Numerous studies have revealed that transdiagnostic interventions for psychological conditions are equally or more efficacious compared to control or comparison conditions (Dalgleish et al., 2020; Gros & Coyne, 2022). Many studies have been published on the short- and long-term effectiveness of transdiagnostic cognitive-behavioural therapy (CBT) for reducing symptoms of anxiety, depression, and PTSD in individuals with mental health conditions (Eskildsen et al., 2020; Ito et al., 2023; O'Donnell et al., 2021; Reinholt et al., 2022; Varkovitzky et al., 2017). In addition to the comparable efficacy with diagnostically separate

treatments, other benefits of the use of transdiagnostic approaches include helping patients to manage comorbid mental health conditions and reducing waitlist times (Titov et al., 2011).

To date, several psychological interventions aimed at reducing pain catastrophizing have been developed. Intervention approaches have varied in structure and content, from web-based psychoeducational approaches to weekly psychotherapy sessions extending over several months. For example, a pain education intervention developed to help individuals with chronic pain learn about pain biology (Gallagher et al., 2013; Moseley, 2007) has been shown to yield significant reductions in pain catastrophizing (Gallagher et al., 2013; Meeus et al., 2010; Moseley et al., 2004). Furthermore, a single-session intervention was developed to target pain catastrophizing using CBT techniques (such as education on pain catastrophizing as well as coping skills to reduce physiological arousal and address catastrophic cognitions) (Darnall et al., 2014). Studies using this intervention have been found to yield significant reductions in pain catastrophizing (Darnall et al., 2021; Darnall et al., 2014; Ziadni et al., 2021). Other researchers have proposed to treat catastrophizing through exposure (Keogh & Cochrane, 2002), though existing evidence on the efficacy of this approach is mixed (Boersma et al., 2019; Hollander et al., 2020; Ryum et al., 2021).

Another interesting approach to address the high rates of mental health comorbidity associated with pain catastrophizing in pain conditions is to adapt existing evidence-based forms of psychotherapy to the context of pain (Day et al., 2019; Linton, 2013). Empirical studies support the effectiveness of psychological intervention, traditionally developed to reduce mental health symptoms, for also addressing pain-related outcomes (Day et al., 2019). Several psychotherapeutic interventions have already been adapted to target pain-related outcomes in addition to mental health outcomes (Dahl et al., 2005; Day, 2017; Thorn, 2017; Vowles &

Sorrell, 2008). A wide range of interventions, including mindfulness-based and cognitive behavioural therapies, have been shown to successfully reduce and maintain reductions of pain catastrophizing levels (Burns et al., 2012; Gardner-Nix et al., 2008; Luciano et al., 2014; Turner et al., 2006).

The results of studies conducted to date suggest that a variety of approaches can yield reductions in pain catastrophizing (Wideman & Sullivan, 2011). However, questions have been raised about the clinical meaningfulness of studies that have been conducted to date. In many of the intervention studies developed to target pain catastrophizing, the average PCS score for the study sample was below previously identified risk thresholds (Gallagher et al., 2013; Meeus et al., 2010; Moseley et al., 2004; Paré et al., 2019; Scott et al., 2014; Ziadni et al., 2021). In addition to low scores on the PCS, it is also important to look beyond statistical significance and consider the magnitude of change in scores when questioning the clinical utility of the PCS. Scott and colleagues (2014) reported that reductions in PCS scores of 38% or greater were best associated with positive recovery outcomes (i.e., pain severity and occupational disability) following whiplash injury. A recent systematic review and meta-analysis found that, despite examining interventions purported to target pain catastrophizing levels, the reduction in catastrophizing was small and of questionable clinical significance (Schutze et al., 2018).

It is possible that the dispositional nature of pain catastrophizing might be one of the factors contributing to challenges in reducing levels of catastrophic thinking. Decades of theoretical and empirical research suggest that pain catastrophizing is, in large part, a trait variable (Campbell et al., 2010; Petrini & Arendt-Nielsen, 2020; Quartana et al., 2009; Sullivan, Thorn, et al., 2001). Indeed, research increasingly points to the genetic etiology of pain catastrophizing. Pain catastrophizing appears to be present early in life and has been found to be

implicated in poor pain-related outcomes in children and adolescents (Feinstein et al., 2017). The heritability index for pain catastrophizing (36-37%) is slightly lower than, but nonetheless comparable to, that which has been reported for other personality traits such as neuroticism (47%) (Boomsma et al., 2018; Burri et al., 2018; Trost et al., 2015). Moreover, latent state-trait modelling on the PCS has revealed that both state and trait features contribute to the variability in item responses from the scale, though trait features were a more important contributor (Dumenci et al., 2020). The trait-like nature of pain catastrophizing could help explain the minimal success in current interventions, which are developed to treat mutable psychological processes rather than personality traits, in reducing levels of pain catastrophizing.

Similarly, it is possible that the ego-syntonic nature of pain catastrophizing is another dimension which helps to explain the treatment resistance of pain catastrophizing. The thought content associated with personality traits is generally experienced as ego-syntonic, or in line with one's self-concept or goals, rather than as a problem requiring change (Hart et al., 2018). Catastrophic thinking can be considered ego-syntonic because it is generally perceived by those experiencing it as functional for managing difficult situations such as health or mental health conditions (Hart et al., 2023; Hart et al., 2018). This cognitive conceptualization of pain catastrophizing is represented in the misdirected problem-solving model, which proposes that pain catastrophizing functions as a cognitive strategy to motivate people living with pain to find biomedical solutions for their pain (Eccleston & Crombez, 2007). However, in focusing on the problem from a biomedical perspective (in the context of pain), the strategies used to address the problem can instead be detrimental and lead to a perseverative loop of increasing levels of pain catastrophizing, persistence in a biomedical understanding of pain, and unresolved pain. As such, the ego-syntonic nature of catastrophic thinking might decrease one's ability to recognize this

cognitive distortion (Beck et al., 1979) and how it contributes to suffering. Furthermore, it is more difficult to change traits that are ego-syntonic, which are often related to personality, as individuals rate lower levels of interest in changing these traits (Sleep et al., 2022).

Concluding remarks

The current thesis aimed to examine the predictive role of pain catastrophizing on the relationships between mental health difficulties and problematic recovery outcomes following whiplash injury. The manuscripts presented in this thesis lend empirical evidence for the clinical utility and pertinence of catastrophizing in the early treatment of whiplash injuries through its relationship with mental health comorbidities. Knowledge gaps remaining in the program of research include the validity of current findings with diagnosed mental health conditions and the mechanisms through which pain catastrophizing impacts mental health outcomes, including how the different subcomponents of pain catastrophizing might be relevant for understanding these mechanisms. Further exploration of these questions will help to advance the assessment and treatment of pain catastrophizing as a risk factor for prolonged and problematic recovery outcomes. Although research over the past several decades has been consistent in demonstrating the robust predictive role of pain catastrophizing in recovery outcomes, the pathways through which outcomes following whiplash injury are impacted by pain catastrophizing have remained relatively unclear. The findings of the studies described in this thesis support the transdiagnostic role of pain catastrophizing as a risk factor for a range of problematic health and mental health outcomes, and argue for continued effort to develop risk-targeted interventions that can yield meaningful reductions in pain catastrophizing.

References

Ackland, H. M., Wolfe, R., Cameron, P. A., Cooper, D. J., Malham, G. M., Varma, D. K., Fitt, G. J., Rosenfeld, J. V., & Liew, S. M. (2012). Health resource utilisation costs in acute patients with persistent midline cervical tenderness following road trauma. *Injury, 43*(11), 1908-1916. https://doi.org/10.1016/j.injury.2012.07.181

Adams, H., Thibault, P., Ellis, T., Moore, E., & Sullivan, M. (2017). The relation between catastrophizing and occupational disability in individuals with Major Depression: Concurrent and prospective associations. *Journal of Occupational Rehabilitation, 27*, 402-412. https://doi.org/10.1007/s10926-016-9669-7

Alhowimel, A., Alodaibi, F., Alotaibi, M., Alamam, D., & Fritz, J. (2021). The patient-reported outcome measures used with low back pain and the attitude of primary healthcare practitioners in Saudi Arabia toward them. *Medicina, 57*(812), 1-9. https://doi.org/10.3390/medicina57080812

Andersen, T. E., Karstoft, K. I., Brink, O., & Elklit, A. (2016). Pain-catastrophizing and fear-avoidance beliefs as mediators between post-traumatic stress symptoms and pain following whiplash injury - A prospective cohort study. *European Journal of Pain, 20*(8), 1241-1252. https://doi.org/10.1002/ejp.848

Angst, F., Francoise, G., Verra, M., Lehmann, S., Jenni, W., & Aeschlimann, A. (2010). Interdisciplinary rehabilitation after whiplash injury: an observational prospective outcome study. *Journal of Rehabilitation Medicine, 42*(4), 350-356. https://doi.org/10.2340/16501977-0530

Angst, F., Gantenbein, A. R., Lehmann, S., Gysi-Klaus, F., Aeschlimann, A., Michel, B. A., & Hegemann, F. (2014). Multidimensional associative factors for improvement in pain, function, and working capacity after rehabilitation of whiplash associated disorder: a prognostic, prospective outcome study. *BMC Musculoskeletal Disorders, 15*(130), 1-9. https://doi.org/10.1186/1471-2474-15-130

Antonakis, J., Bendahan, S., Jacquart, P., & Lalive, R. (2010). On making causal claims: A review and recommendations. *The Leadership Quarterly, 21*(6), 1086-1120. https://doi.org/10.1016/j.leaqua.2010.10.010

Asmundson, G. J., Coons, M. J., Taylor, S., & Katz, J. (2002). PTSD and the experience of pain: research and clinical implications of shared vulnerability and mutual maintenance models. *Canadian Journal of Psychiatry, 47*(10), 930-937.

Bair, M. J., Robinson, R. L., Katon, W., & Kroenke, K. (2003). Depression and pain comorbidity: a literature review. *Archives of Internal Medicine, 163*(20), 2433-2445.

Baltov, P., Cote, J., Truchon, M., & Feldman, D. E. (2008). Psychosocial and socio-demographic factors associated with outcomes for patients undergoing rehabilitation for chronic whiplash associated disorders: a pilot study. *Disability and Rehabilitation, 30*(25), 1947-1955. https://doi.org/10.1080/09638280701791245

Baribeau, D. A., Vigod, S., Brittain, H., Vaillancourt, T., Szatmari, P., & Pullenayegum, E. (2022). Application of transactional (cross-lagged panel) models in mental health research - An introduction and review of methodological considerations. *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 31*(3), 124-134.

Barlow, D. H., Allen, L. B., & Choate, M. L. (2004). Toward a unified treatment for emotional disorders. *Behaviour Therapy, 35*, 205-230.

Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive Therapy of Depression*. The Guilford Press.

Beck, A. T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory - II*. Psychological Corporation.

Beck, J. G., & Clapp, J. D. (2011). A different kind of co-morbidity: Understanding posttraumatic stress disorder and chronic pain. *Psychological Trauma: Theory, Research, Practice, and Policy, 3*(2), 101-108. https://doi.org/10.1037/a0021263

Beck, J. G., Grant, D. M., Read, J. P., Clapp, J. D., Coffey, S. F., Miller, L. M., & Palyo, S. A. (2008). The Impact of Event Scale - Revised: Psychometric properties in a sample of motor vehicle accident survivors. *Journal of Anxiety Disorders, 22*(2), 187-198. https://doi.org/10.1016/j.janxdis.2007.02.007

Beierl, E. T., Bollinghaus, I., Clark, D. M., Glucksman, E., & Ehlers, A. (2020). Cognitive paths from trauma to posttraumatic stress disorder: a prospective study of Ehlers and Clark's model in survivors of assaults or road traffic collisions. *Psychological Medicine, 50*(13), 2172-2181. https://doi.org/10.1017/S0033291719002253

Besen, E., Young, A. E., & Shaw, W. S. (2015). Returning to work following low back pain: towards a model of individual psychosocial factors. *Journal of Occupational Rehabilitation, 25*(1), 25-37. https://doi.org/10.1007/s10926-014-9522-9

Birch, S., Stilling, M., Mechlenburg, I., & Hansen, T. B. (2019). The association between pain catastrophizing, physical function and pain in a cohort of patients undergoing knee arthroplasty. *BMC Musculoskeletal Disorders, 20*(1), 421. https://doi.org/10.1186/s12891-019-2787-6

Bishop, S. R., Edgley, K., Fisher, R., & Sullivan, M. J. L. (1993). Screening for depression in chronic low back pain with the Beck Depression Inventory. *Canadian Journal of Rehabilitation, 7*, 143-148.

Blincoe, L., Seay, A., Zaloshnja, E., Miller, T. M., Romano, E., Luchter, S., & Spicer, R. (2002). *The economic impact of motor vehicle crashes*. National Highway Traffic Safety Administration.

Boersma, K., & Linton, S. J. (2006). Psychological processes underlying the development of a chronic pain problem: a prospective study of the relationship between profiles of psychological variables in the fear-avoidance model and disability. *The Clinical Journal of Pain, 22*(2), 160-166. https://doi.org/00002508-200602000-00007

Boersma, K., Sodermark, M., Hesser, H., Flink, I. K., Gerdle, B., & Linton, S. J. (2019). Efficacy of a transdiagnostic emotion-focused exposure treatment for chronic pain patients with comorbid anxiety and depression: a randomized controlled trial. *Pain, 160*(8), 1708-1718. https://doi.org/10.1097/j.pain.0000000000001575

Boomsma, D. I., Helmer, Q., Nieuwboer, H. A., Hottenga, J. J., de Moor, M. H., van den Berg, S. M., Davies, G. E., Vink, J. M., Schouten, M. J., Dolan, C. V., Willemsen, G., Bartels, M., van Beijsterveldt, T., Ligthart, L., & de Geus, E. J. (2018). An extended twin-pedigree study of neuroticism in the Netherlands Twin Register. *Behavior Genetics, 48*(1), 1-11. https://doi.org/10.1007/s10519-017-9872-0

Boonstra, A. M., Stewart, R. E., Koke, A. J., Oosterwijk, R. F., Swaan, J. L., Schreurs, K. M., & Schiphorst Preuper, H. R. (2016). Cut-off points for mild, moderate, and severe pain on the Numeric Rating Scale for pain in patients with chronic musculoskeletal pain: Variability and influence of sex and catastrophizing. *Frontiers in Psychology, 7*, 1466. https://doi.org/10.3389/fpsyg.2016.01466

Borsbo, B., Peolsson, M., & Gerdle, B. (2009). The complex interplay between pain intensity, depression, anxiety and catastrophising with respect to quality of life and disability. *Disability and Rehabilitation, 31*(19), 1605-1613. https://doi.org/10.1080/09638280903110079

Bortsov, A. V., Platts-Mills, T. F., Peak, D. A., Jones, J. S., Swor, R. A., Domeier, R. M., Lee, D. C., Rathlev, N. K., Hendry, P. L., Fillingim, R. B., & McLean, S. A. (2013). Pain distribution and predictors of widespread pain in the immediate aftermath of motor vehicle collision. *European Journal of Pain, 17*(8), 1243-1251. https://doi.org/10.1002/j.1532-2149.2013.00285.x

Bostick, G. P., Carroll, L. J., Brown, C. A., Harley, D., & Gross, D. P. (2013). Predictive capacity of pain beliefs and catastrophizing in Whiplash Associated Disorder. *Injury, 44*(11), 1465-1471. https://doi.org/10.1016/j.injury.2012.10.007

Brunet, A., St-Hilaire, A., Jehel, L., & King, S. (2002). Validation of the French version of the Impact of Event Scale - Revised. *Canadian Journal of Psychiatry, 20*, 174-182.

Buenaver, L. F., Edwards, R. R., Smith, M. T., Gramling, S. E., & Haythornthwaite, J. A. (2008). Catastrophizing and pain-coping in young adults: associations with depressive symptoms and headache pain. *The Journal of Pain, 9*(4), 311-319. https://doi.org/10.1016/j.jpain.2007.11.005

Buitenhuis, J., de Jong, P. J., Jaspers, J. P., & Groothoff, J. W. (2006). Relationship between posttraumatic stress disorder symptoms and the course of whiplash complaints. *Journal of Psychosomatic Research, 61*(5), 681-689. https://doi.org/10.1016/j.jpsychores.2006.07.008

Bunzli, S., Maujean, A., Andersen, T. E., & Sterling, M. (2019). Whiplash patients' responses on the Impact of Events Scale-R: Congruent with pain or PTSD symptoms? *The Clinical Journal of Pain, 35*(3), 229-237. https://doi.org/10.1097/AJP.0000000000000665

Burns, J. W., Day, M. A., & Thorn, B. E. (2012). Is reduction in pain catastrophizing a therapeutic mechanism specific to cognitive-behavioral therapy for chronic pain? *Translational Behavioral Medicine, 2*(1), 22-29. https://doi.org/10.1007/s13142-011-0086-3

Burns, J. W., Gerhart, J., Van Dyke, B. P., Morais, C. A., Newman, A. K., & Thorn, B. (2021). Examination of mechanism effects in cognitive behavioral therapy and pain education: analyses of weekly assessments. *Pain, 162*(9), 2446-2455. https://doi.org/10.1097/j.pain.0000000000002237

Burns, J. W., Kubilus, A., Bruehl, S., Harden, R. N., & Lofland, K. (2003). Do changes in cognitive factors influence outcome following multidisciplinary treatment for chronic pain? A cross-lagged panel analysis. *Journal of Consulting and Clinical Psychology, 71*(1), 81-91. https://doi.org/10.1037/0022-006x.71.1.81

Burri, A., Ogata, S., Rice, D., & Williams, F. (2018). Pain catastrophizing, neuroticism, fear of pain, and anxiety: Defining the genetic and environmental factors in a sample of female twins. *PLOS One, 13*(3), e0194562. https://doi.org/10.1371/journal.pone.0194562

Campbell, C. M., Kronfli, T., Buenaver, L. F., Smith, M. T., Berna, C., Haythornthwaite, J. A., & Edwards, R. R. (2010). Situational versus dispositional measurement of catastrophizing: associations with pain responses in multiple samples. *The Journal of Pain, 11*(5), 443-453. https://doi.org/10.1016/j.jpain.2009.08.009

Campbell, C. M., McCauley, L., Bounds, S. C., Mathur, V. A., Conn, L., Simango, M., Edwards, R. R., & Fontaine, K. R. (2012). Changes in pain catastrophizing predict later changes in fibromyalgia clinical and experimental pain report: cross-lagged panel analyses of

dispositional and situational catastrophizing. *Arthritis Research & Therapy, 14*(5), R231. https://doi.org/10.1186/ar4073

Carriere, J. S., Lazaridou, A., Martel, M. O., Cornelius, M., Campbell, C., Smith, M., Haythornthwaite, J. A., & Edwards, R. R. (2020). The moderating role of pain catastrophizing on the relationship between partner support and pain intensity: a daily diary study in patients with knee osteoarthritis. *Journal of Behavioral Medicine, 43*(5), 807-816. https://doi.org/10.1007/s10865-019-00121-5

Carriere, J. S., Thibault, P., Milioto, M., & Sullivan, M. J. L. (2015). Expectancies mediate the relations among pain catastrophizing, fear of movement, and return to work after whiplash injury. *The Journal of Pain, 16*, 1280 - 1287.

Carriere, J. S., Thibault, P., & Sullivan, M. J. (2015). The mediating role of recovery expectancies on the relation between depression and return-to-work. *Journal of Occupational Rehabilitation, 25*(2), 348-356. https://doi.org/10.1007/s10926-014-9543-4

Carroll, L. J., Holm, L. W., Hogg-Johnson, S., Cote, P., Cassidy, J. D., Haldeman, S., Nordin, M., Hurwitz, E. L., Carragee, E. J., van der Velde, G., Peloso, P. M., & Guzman, J. (2008). Course and prognostic factors for neck pain in whiplash-associated disorders (WAD): results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. *Spine, 33*(4 Suppl), S83-92. https://doi.org/10.1097/BRS.0b013e3181643eb800007632-200802151-00013

Carstensen, T. B. (2012). The influence of psychosocial factors on recovery following acute whiplash trauma. *Danish Medical Journal, 59*(12), B4560. https://www.ncbi.nlm.nih.gov/pubmed/23290295

Carty, J., O'Donnell, M., Evans, L., Kazantzis, N., & Creamer, M. (2011). Predicting posttraumatic stress disorder symptoms and pain intensity following severe injury: the role of catastrophizing. *European Journal of Psychotraumatology, 2*(1), 5652. https://doi.org/10.3402/ejpt.v2i0.5652

Casey, P. P., Feyer, A. M., & Cameron, I. D. (2011). Identifying predictors of early non-recovery in a compensation setting: The Whiplash Outcome Study. *Injury, 42*(1), 25-32. https://doi.org/10.1016/j.injury.2010.07.234

Casey, P. P., Feyer, A. M., & Cameron, I. D. (2015). Course of recovery for whiplash associated disorders in a compensation setting. *Injury, 46*(11), 2118-2129. https://doi.org/10.1016/j.injury.2015.08.038

Cassidy, J. D., Carroll, L. J., Cote, P., Lemstra, M., Berglund, A., & Nygren, A. (2000). Effect of eliminating compensation for pain and suffering on the outcome of insurance claims for

whiplash injury. *The New England Journal of Medicine, 342*(16), 1179-1186. https://doi.org/10.1056/NEJM200004203421606

Chaves, J. F., & Brown, J. M. (1978). *Self-generated strategies for the control of pain and stress.* Annual Meeting of the American Psychological Association, Toronto, ON.

Chaves, J. F., & Brown, J. M. (1987). Spontaneous cognitive strategies for the control of clinical pain and stress. *Journal of Behavioral Medicine, 10*, 263 - 276.

Cheng, S. T., Chen, P. P., Chow, Y. F., Chung, J. W. Y., Law, A. C. B., Lee, J. S. W., Leung, E. M. F., & Tam, C. W. C. (2019). The Pain Catastrophizing Scale-short form: psychometric properties and threshold for identifying high-risk individuals. *International Psychogeriatrics, 31*(11), 1665-1674. https://doi.org/10.1017/S1041610219000024

Christensen, K. S., O'Sullivan, K., & Palsson, T. S. (2020). Conditioned pain modulation efficiency is associated with pain catastrophizing in patients with chronic low back pain. *The Clinical Journal of Pain, 36*(11), 825-832. https://doi.org/10.1097/AJP.0000000000000878

Chung, K. F., Tso, K. C., Yeung, W. F., & Li, W. H. (2012). Quality of life in major depressive disorder: the role of pain and pain catastrophizing cognition. *Comprehensive Psychiatry, 53*(4), 387-395. https://doi.org/10.1016/j.comppsych.2011.05.005

Ciccone, D. S., & Kline, A. (2012). A longitudinal study of pain and pain catastrophizing in a cohort of National Guard troops at risk for PTSD. *Pain, 153*(10), 2055-2060. https://doi.org/10.1016/j.pain.2012.06.015

Coggon, D., Ntani, G., Palmer, K. T., Felli, V. E., Harari, R., Barrero, L. H., Felknor, S. A., Gimeno, D., Cattrell, A., Vargas-Prada, S., Bonzini, M., Solidaki, E., Merisalu, E., Habib, R. R., Sadeghian, F., Masood Kadir, M., Warnakulasuriya, S. S., Matsudaira, K., Nyantumbu, B., Sim, M. R., Harcombe, H., Cox, K., Marziale, M. H., Sarquis, L. M., Harari, F., Freire, R., Harari, N., Monroy, M. V., Quintana, L. A., Rojas, M., Salazar Vega, E. J., Harris, E. C., Serra, C., Martinez, J. M., Delclos, G., Benavides, F. G., Carugno, M., Ferrario, M. M., Pesatori, A. C., Chatzi, L., Bitsios, P., Kogevinas, M., Oha, K., Sirk, T., Sadeghian, A., Peiris-John, R. J., Sathiakumar, N., Wickremasinghe, A. R., Yoshimura, N., Kelsall, H. L., Hoe, V. C., Urquhart, D. M., Derrett, S., McBride, D., Herbison, P., & Gray, A. (2013). Patterns of multisite pain and associations with risk factors. *Pain, 154*(9), 1769-1777. https://doi.org/10.1016/j.pain.2013.05.039

Cote, P., Cassidy, J. D., & Carroll, L. (2001). The treatment of neck and low back pain: Who seeks care? Who goes where? *Medical Care, 39*(9), 956-967.

Cote, P., Wong, J. J., Sutton, D., Shearer, H. M., Mior, S., Randhawa, K., Ameis, A., Carroll, L. J., Nordin, M., Yu, H., Lindsay, G. M., Southerst, D., Varatharajan, S., Jacobs, C., Stupar, M.,

Taylor-Vaisey, A., van der Velde, G., Gross, D. P., Brison, R. J., Paulden, M., Ammendolia, C., David Cassidy, J., Loisel, P., Marshall, S., Bohay, R. N., Stapleton, J., Lacerte, M., Krahn, M., & Salhany, R. (2016). Management of neck pain and associated disorders: A clinical practice guideline from the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration. *European Spine Journal, 25*(7), 2000-2022. https://doi.org/10.1007/s00586-016-4467-7

Craner, J. R., Gilliam, W. P., & Sperry, J. A. (2016). Rumination, magnification, and helplessness: How do different aspects of pain catastrophizing relate to pain severity and functioning? *The Clinical Journal of Pain, 32*(12), 1028-1035. https://doi.org/10.1097/AJP.0000000000000355

Creamer, M., Bell, R., & Failla, S. (2003). Psychometric properties of the Impact of Event Scale - Revised. *Behavior Research and Therapy, 41*(12), 1489-1496.

Crombez, G., Eccleston, C., Baeyens, F., & Eelen, P. (1998). When somatic information threatens, catastrophic thinking enhances attentional interference. *Pain, 75*, 187 - 198.

da Silva, T., Macaskill, P., Mills, K., Maher, C., Williams, C., Lin, C., & Hancock, M. J. (2017). Predicting recovery in patients with acute low back pain: A Clinical Prediction Model. *European Journal of Pain, 21*(4), 716-726. https://doi.org/10.1002/ejp.976

Dahl, J. C., Wilson, K. G., Luciano, C., & Hayes, S. C. (2005). *Acceptance and Commitment Therapy for Chronic Pain*. Context Press.

Dalgleish, T., Black, M., Johnston, D., & Bevan, A. (2020). Transdiagnostic approaches to mental health problems: Current status and future directions. *Journal of Consulting and Clinical Psychology, 88*(3), 179-195. https://doi.org/10.1037/ccp0000482

Darnall, B. D., Roy, A., Chen, A. L., Ziadni, M. S., Keane, R. T., You, D. S., Slater, K., Poupore-King, H., Mackey, I., Kao, M. C., Cook, K. F., Lorig, K., Zhang, D., Hong, J., Tian, L., & Mackey, S. C. (2021). Comparison of a single-session pain management skills intervention with a single-session health education intervention and 8 sessions of cognitive behavioral therapy in adults With chronic low back pain: A randomized clinical trial. *JAMA Network Open, 4*(8), e2113401. https://doi.org/10.1001/jamanetworkopen.2021.13401

Darnall, B. D., Sturgeon, J. A., Kao, M. C., Hah, J. M., & Mackey, S. C. (2014). From Catastrophizing to Recovery: a pilot study of a single-session treatment for pain catastrophizing. *Journal of Pain Research, 7*, 219-226. https://doi.org/10.2147/JPR.S62329

Day, M. A. (2017). *Mindfulness-Based Cognitive Therapy for Chronic Pain: A Clinical Manual and Guide*. Wiley.

Day, M. A., Smitherman, A., Ward, L. C., & Thorn, B. E. (2015). An investigation of the associations between measures of mindfulness and pain catastrophizing. *The Clinical Journal of Pain, 31*(3), 222-228. https://doi.org/10.1097/AJP.0000000000000102

Day, M. A., Ward, L. C., Ehde, D. M., Thorn, B. E., Burns, J., Barnier, A., Mattingley, J. B., & Jensen, M. P. (2019). A pilot randomized controlled trial comparing mindfulness meditation, cognitive therapy, and mindfulness-based cognitive therapy for chronic low back pain. *Pain Medicine, 20*(11), 2134-2148. https://doi.org/10.1093/pm/pny273

de Heer, E. W., Ten Have, M., van Marwijk, H. W. J., Dekker, J., de Graaf, R., Beekman, A. T. F., & van der Feltz-Cornelis, C. M. (2018). Pain as a risk factor for common mental disorders. Results from the Netherlands Mental Health Survey and Incidence Study-2: a longitudinal, population-based study. *Pain, 159*(4), 712-718. https://doi.org/10.1097/j.pain.0000000000001133

DeRubeis, R. J., Evans, M. D., Hollon, S. D., Garvey, M. J., Grove, W. M., & Tuason, V. B. (1991). How does cognitive therapy work? Cognitive change and symptom change in cognitive therapy and pharmacotherapy for depression. *Journal of Consulting and Clinical Psychology, 58*(6), 862-869.

Donayre Pimentel, S., Adams, H., Ellis, T., Clark, R., Sully, C., Paré, C., & Sullivan, M. J. (2020). The sequential relation between changes in catastrophizing and changes in posttraumatic stress disorder symptom severity. *Journal of Traumatic Stress, 33*(5), 731-740. https://doi.org/10.1002/jts.22519

Dumenci, L., Kroenke, K., Keefe, F. J., Ang, D. C., Slover, J., Perera, R. A., & Riddle, D. L. (2020). Disentangling trait versus state characteristics of the Pain Catastrophizing Scale and the PHQ-8 Depression Scale. *European Journal of Pain, 24*(8), 1624-1634. https://doi.org/10.1002/ejp.1619

Dunne, R. L., Kenardy, J., & Sterling, M. (2012). A randomized controlled trial of cognitive-behavioural therapy for the treatment of PTSD in the context of chronic whiplash. *Clinical Journal of Pain, 28*(9), 755-765.

Eccleston, C., & Crombez, G. (2007). Worry and chronic pain: a misdirected problem solving model. *Pain, 132*(3), 233-236. https://doi.org/10.1016/j.pain.2007.09.014

Edwards, R. R., Bingham, C. O., 3rd, Bathon, J., & Haythornthwaite, J. A. (2006). Catastrophizing and pain in arthritis, fibromyalgia, and other rheumatic diseases. *Arthritis and Rheumatism, 55*(2), 325-332. https://doi.org/10.1002/art.21865

Edwards, R. R., Dworkin, R. H., Sullivan, M. D., Turk, D. C., & Wasan, A. D. (2016). The role of psychosocial processes in the development and maintenance of chronic pain. *The Journal of Pain, 17*(9 Suppl), T70-92. https://doi.org/10.1016/j.jpain.2016.01.001

Edwards, R. R., Smith, M. T., Stonerock, G., & Haythornthwaite, J. A. (2006). Pain-related catastrophizing in healthy women is associated with greater temporal summation of and reduced habituation to thermal pain. *The Clinical Journal of Pain, 22*(8), 730-737.

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behavior Research and Therapy, 38*(4), 319-345. https://doi.org/S0005-7967(99)00123-0

Elhamiasl, M., Dehghani, M., Heidari, M., & Khatibi, A. (2020). The relationship between ruminating the catastrophic consequences of bodily changes and positive reappraisal and practical problem-solving strategies in individuals with Illness Anxiety Disorder. *Basic and Clinical Neuroscience, 11*(5), 639-648. https://doi.org/10.32598/bcn.9.10.240

Ellis, A. (1962). *Reason and emotion in psychotherapy*. Lyle Stuart.

Erford, B. T., Johnson, E., & Bardoshi, G. (2016). Meta-Analysis of the English Version of the Beck Depression Inventory–Second Edition. *Measurement and Evaluation in Counseling and Development, 49*(1), 3-33. https://doi.org/10.1177/0748175615596783

Eskildsen, A., Reinholt, N., van Bronswijk, S., Brund, R. B. K., Christensen, A. B., Hvenegaard, M., Arendt, M., Alrø, A., Poulsen, S., Rosenberg, N. K., Huibers, M. J. H., & Arnfred, S. (2020). Personalized psychotherapy for outpatients with Major Depression and anxiety disorders: Transdiagnostic versus diagnosis-specific group cognitive behavioural therapy. *Cognitive Therapy and Research, 44*(5), 988-1001. https://doi.org/10.1007/s10608-020-10116-1

Farinha-Fernandes, A., Conceição, N., & Silva, R. (2020). Categories of transdiagnostic processes: Qualitative data from psychotherapy practitioners. *Counselling and Psychotherapy Research, 21*(3), 652-659. https://doi.org/10.1002/capr.12348

Farrar, J. T., Young, J. P., LaMoreaux, L., Werth, J. L., & Poole, R. M. (2001). Clinical importance of changes in pain intensity measured on an 11-point numerical pain rating scale. *Pain, 94*, 149 - 158.

Fedak, K. M., Bernal, A., Capshaw, Z. A., & Gross, S. (2015). Applying the Bradford Hill criteria in the 21st century - How data integration has changed causal inference in molecular epidemiology. *Emerging Themes in Epidemiology, 12*(14). https://doi.org/10.1186/s12982-015-0037-4

Feinstein, A. B., Sturgeon, J. A., Darnall, B. D., Dunn, A. L., Rico, T., Kao, M. C., & Bhandari, R. P. (2017). The effect of pain catastrophizing on outcomes: A developmental perspective across children, adolescents, and young adults with chronic pain. *The Journal of Pain, 18*(2), 144-154. https://doi.org/10.1016/j.jpain.2016.10.009

Ferrari, R., & Schrader, H. (2001). The late whiplash syndrome: A biopsychosocial approach. *Journal of Neurology, Neurosurgery and Psychiatry, 71*, 722-726.

Ferreira-Valente, M. A., Pais-Ribeiro, J. L., & Jensen, M. P. (2011). Validity of four pain intensity rating scales. *Pain, 152*(10), 2399-2404. https://doi.org/10.1016/j.pain.2011.07.005

Flink, I. L., Boersma, K., & Linton, S. J. (2013). Pain catastrophizing as repetitive negative thinking: a development of the conceptualization. *Cognitive Behaviour Therapy, 42*(3), 215-223. https://doi.org/10.1080/16506073.2013.769621

Foreman, S. M., & Croft, A. C. (2002). *Whiplash Injuries: The Cervical Acceleration/Deceleration Syndrome*. Lippincott Williams Wilkins.

Gallagher, L., McAuley, J., & Moseley, G. L. (2013). A randomized-controlled trail of using a book of metaphors to reconceptualize pain and decrease catastrophizing in people with chronic pain. *The Clinical Journal of Pain, 29*, 20-25.

Gallagher, M. W. (2017). Transdiagnostic mechanisms of change and cognitive-behavioral treatments for PTSD. *Current Opinions in Psychology, 14*, 90-95. https://doi.org/10.1016/j.copsyc.2016.12.002

Gardner-Nix, J., Backman, S., Barbati, J., & Grummitt, J. (2008). Evaluating distance education of a mindfulness-based meditation programme for chronic pain management. *Journal of Telemedicine and Telecare, 14*(2), 88-92. https://doi.org/10.1258/jtt.2007.070811

Garnefski, N., & Kraaij, V. (2007). The Cognitive Emotion Regulation Questionnaire - Psychometric features and prospective relationships with depression and anxiety in adults. *European Journal of Psychological Assessment, 23*(3), 141-149. https://doi.org/10.1027/1015-5759.23.3.141

Gauthier, N., Thibault, P., & Sullivan, M. J. L. (2011). Catastrophizers with chronic pain display more pain behaviour when in a relationship with a low catastrophizing spouse. *Pain Research & Management, 16*(5), 293-299.

Geisser, M. E., Robinson, M. E., Keefe, F. J., & Weiner, M. L. (1994). Catastrophizing, depression and the sensory, affective and evaluative aspects of chronic pain. *Pain, 59*(1), 79-83. https://doi.org/0304-3959(94)90050-7

Geisser, M. E., Roth, R. S., & Robinson, M. E. (1997, Jun). Assessing depression among persons with chronic pain using the Center for Epidemiological Studies-Depression Scale and the Beck Depression Inventory: a comparative analysis. *The Clinical Journal of Pain, 13*(2), 163-170. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=9186024

Gellatly, R., & Beck, A. T. (2016). Catastrophic thinking: A transdiagnostic process across psychiatric disorders. *Cognitive Therapy and Research, 40*(4), 441-452. https://doi.org/10.1007/s10608-016-9763-3

George, S. Z., Wittmer, V. T., Fillingim, R. B., & Robinson, M. E. (2007). Sex and pain-related psychological variables are associated with thermal pain sensitivity for patients with chronic low back pain. *The Journal of Pain, 8*(1), 2-10. https://doi.org/10.1016/j.jpain.2006.05.009

Gilliam, W. P., Craner, J. R., Morrison, E. J., & Sperry, J. A. (2017). The mediating effects of the different dimensions of pain catastrophizing on outcomes in an interdisciplinary pain rehabilitation program. *The Clinical Journal of Pain, 33*(5), 443-451. https://doi.org/10.1097/AJP.0000000000000419

Gilliam, W. P., Craner, J. R., Schumann, M. E., & Gascho, K. (2019). The mediating effect of pain catastrophizing on PTSD symptoms and pain outcome. *The Clinical Journal of Pain, 35*(7), 583-588. https://doi.org/10.1097/AJP.0000000000000713

Giummarra, M. J., Casey, S. L., Devlin, A., Ioannou, L. J., Gibson, S. J., Georgiou-Karistianis, N., Jennings, P. A., Cameron, P. A., & Ponsford, J. (2017). Co-occurrence of posttraumatic stress symptoms, pain, and disability 12 months after traumatic injury. *Pain Reports, 2*(5), e622. https://doi.org/10.1097/PR9.0000000000000622

Glette, M., Stiles, T. C., Jensen, M. P., Nilsen, T. I. L., Borchgrevink, P. C., & Landmark, T. (2021). Impact of pain and catastrophizing on the long-term course of depression in the general population: the HUNT pain study. *Pain, 162*(6), 1650-1658. https://doi.org/10.1097/j.pain.0000000000002168

Goodin, B. R., McGuire, L., Allshouse, M., Stapleton, L., Haythornthwaite, J. A., Burns, N., Mayes, L. A., & Edwards, R. R. (2009). Associations between catastrophizing and endogenous pain-inhibitory processes: sex differences. *The Journal of Pain, 10*(2), 180-190. https://doi.org/10.1016/j.jpain.2008.08.012

Gopinath, B., Jagnoor, J., Nicholas, M., Blyth, F., Harris, I. A., Casey, P., & Cameron, I. D. (2015). Presence and predictors of persistent pain among persons who sustained an injury in a road traffic crash. *European Journal of Pain, 19*(8), 1111-1118. https://doi.org/10.1002/ejp.634

Gracely, R. H., Geisser, M. E., Giesecke, T., Grant, M. A., Petzke, F., Williams, D. A., & Clauw, D. J. (2004). Pain catastrophizing and neural responses to pain among persons with fibromyalgia. *Brain, 127*(Pt 4), 835-843. https://doi.org/10.1093/brain/awh098

Granot, M., Granovsky, Y., Sprecher, E., Nir, R. R., & Yarnitsky, D. (2006). Contact heat-evoked temporal summation: tonic versus repetitive-phasic stimulation. *Pain, 122*(3), 295-305. https://doi.org/10.1016/j.pain.2006.02.003

Gros, D. F., & Coyne, A. E. (2022). A comparison of transdiagnostic behavior therapy (TBT) and behavioral activation treatment for depression (BATD) in veterans with major depressive disorder. *Journal of Clinical Psychology, 78*(6), 1009-1019. https://doi.org/10.1002/jclp.23298

Grosen, K., Vase, L., Pilegaard, H. K., Pfeiffer-Jensen, M., & Drewes, A. M. (2014). Conditioned pain modulation and situational pain catastrophizing as preoperative predictors of pain following chest wall surgery: a prospective observational cohort study. *PLOS One, 9*(2), e90185. https://doi.org/10.1371/journal.pone.0090185

Haaga, D. A. (1992). Catastrophizing, confounds, and depression: a comment on Sullivan and D'Eon (1990). *Journal of Abnormal Psychology, 101*(1), 206-207. http://www.ncbi.nlm.nih.gov/pubmed/1537968

Hart, W., Cease, C. K., Lambert, J. T., & Witt, D. E. (2023). Revisiting the ego-syntonic assumption: Investigating neuroticism and harmony with thoughts of negative emotions. *Personality Disorders: Theory, Research, and Treatment*. https://doi.org/10.1037/per0000620

Hart, W., Tortoriello, G. K., & Richardson, K. (2018). Are personality disorder traits ego-syntonic or ego-dystonic? Revisiting the issue by considering functionality. *Journal of Research in Personality, 76*, 124-128. https://doi.org/10.1016/j.jrp.2018.08.001

Heathcote, L. C., Koopmans, M., Eccleston, C., Fox, E., Jacobs, K., Wilkinson, N., & Lau, J. Y. (2016). Negative interpretation bias and the experience of pain in adolescents. *The Journal of Pain, 17*(9), 972-981. https://doi.org/10.1016/j.jpain.2016.05.009

Heathcote, L. C., Vervoort, T., Eccleston, C., Fox, E., Jacobs, K., Van Ryckeghem, D. M. L., & Lau, J. Y. F. (2015). The relationship between adolescents' pain catastrophizing and attention bias to pain faces is moderated by attention control. *Pain, 156*(7), 1334-1341. https://doi.org/10.1097/j.pain.0000000000000174

Hefner, K., & Rosenheck, R. (2019, Jun). Multimorbidity among Veterans Diagnosed with PTSD in the Veterans Health Administration Nationally. *The Psychiatric quarterly, 90*(2), 275-291. https://doi.org/10.1007/s11126-019-09632-5

Hjermstad, M. J., Fayers, P. M., Haugen, D. F., Caraceni, A., Hanks, G. W., Loge, J. H., Fainsinger, R., Aass, N., Kaasa, S., & European Palliative Care Research Collaborative. (2011). Studies comparing Numerical Rating Scales, Verbal Rating Scales, and Visual Analogue Scales for assessment of pain intensity in adults: a systematic literature review. *Journal of Pain and*

Symptom Management, 41(6), 1073-1093. https://doi.org/10.1016/j.jpainsymman.2010.08.016

Hollander, M. D., de Jong, J., Onghena, P., & Vlaeyen, J. W. S. (2020). Generalization of exposure in vivo in Complex Regional Pain Syndrome type I. *Behavior Research and Therapy, 124*, 103511. https://doi.org/10.1016/j.brat.2019.103511

Hulsebusch, J., Hasenbring, M. I., & Rusu, A. C. (2016). Understanding pain and depression in back pain: the role of catastrophizing, help-/hopelessness, and thought suppression as potential mediators. *International Journal of Behavioral Medicine, 23*(3), 251-259. https://doi.org/10.1007/s12529-015-9522-y

International Classification of Functioning, Disability and Health (ICF). (2001). WHO.

IsHak, W. W., Wen, R. Y., Naghdechi, L., Vanle, B., Dang, J., Knosp, M., Dascal, J., Marcia, L., Gohar, Y., Eskander, L., Yadegar, J., Hanna, S., Sadek, A., Aguilar-Hernandez, L., Danovitch, I., & Louy, C. (2018). Pain and depression: A systematic review. *Harvard Review of Psychiatry, 26*(6), 352-363. https://doi.org/10.1097/HRP.0000000000000198

Ito, M., Horikoshi, M., Kato, N., Oe, Y., Fujisato, H., Yamaguchi, K., Nakajima, S., Miyamae, M., Toyota, A., Okumura, Y., & Takebayashi, Y. (2023). Efficacy of the unified protocol for transdiagnostic cognitive-behavioral treatment for depressive and anxiety disorders: a randomized controlled trial. *Psychological Medicine, 53*(7), 3009-3020. https://doi.org/10.1017/S0033291721005067

Jenness, J. L., Jager-Hyman, S., Heleniak, C., Beck, A. T., Sheridan, M. A., & McLaughlin, K. A. (2016). Catastrophizing, rumination, and reappraisal prospectively predict adolescent PTSD symptom onset following a terrorist attack. *Depression and Anxiety*. https://doi.org/10.1002/da.22548

Jensen, M. P., Turner, J. A., Romano, J. M., & Fisher, L. D. (1999). Comparative reliability and validity of chronic pain intensity measures. *Pain, 83*(2), 157-162. https://doi.org/S0304395999001013

Jones, E. B., Sharpe, L., Andrews, S., Colagiuri, B., Dudeney, J., Fox, E., Heathcote, L. C., Lau, J. Y. F., Todd, J., Van Damme, S., Van Ryckeghem, D. M. L., & Vervoort, T. (2021). The time course of attentional biases in pain: a meta-analysis of eye-tracking studies. *Pain, 162*(3), 687-701. https://doi.org/10.1097/j.pain.0000000000002083

Joslin, C. C., Khan, S. N., & Bannister, G. C. (2004). Long-term disability after neck injury - A comparative study. *The Journal of Bone and Joint Surgery (Br), 86B*, 1032-1034. https://doi.org/10.1302/0301-620X.86B7

Jull, G. A., Sterling, M., Curatolo, M., Carroll, L., & Hodges, P. (2011). Toward lessening the rate of transition of acute whiplash to a chronic disorder. *Spine, 36*(25 Suppl), S173-174. https://doi.org/10.1097/BRS.0b013e31823883e6

Kearney, M. W. (2017). Cross-lagged panel analysis. In M. R. Allen (Ed.), *Sage Encyclopedia of Communication Research Methods*. Sage Publications.

Keefe, F., Lefebvre, J., & Smith, S. (1999). Catastrophizing research: Avoiding conceptual errors and maintaining a balnaced perspective. *Pain Forum, 8*, 176-180.

Keefe, F. J., Lefebvre, J. C., Egert, J. R., Affleck, G., Sullivan, M. J. L., & Caldwell, D. S. (2000). The relationship of gender to pain, pain behavior, and disability in osteoarthritis patients: the role of catastrophizing. *Pain, 87*(3), 325-334. http://www.ncbi.nlm.nih.gov/pubmed/10963912

Kenny, D. A. (1975). Cross-lagged panel correlation - A test for spuriousness. *Psychological Bulletin, 82*, 887-903.

Keogh, E., & Cochrane, M. (2002). Anxiety sensitivity, cognitive biases, and the experience of pain. *The Journal of Pain, 3*(4), 320-329. https://doi.org/10.1054/jpai.2002.125182

Khatibi, A., Schrooten, M. G., Vancleef, L. M., & Vlaeyen, J. W. (2014). An experimental examination of catastrophizing-related interpretation bias for ambiguous facial expressions of pain using an incidental learning task. *Frontiers in Psychology, 5*, 1002. https://doi.org/10.3389/fpsyg.2014.01002

Laporte, S., Wang, D., Lecompte, J., Blancho, S., Sandoz, B., Feydy, A., Lindberg, P., Adrian, J., Chiarovano, E., de Waele, C., & Vidal, P. P. (2016). An attempt of early detection of poor outcome after whiplash. *Frontiers in Neurology, 7*, 177. https://doi.org/10.3389/fneur.2016.00177

Laurenceau, J.-P., Hayes, A. M., & Feldman, G. C. (2007). Some methodological and statistical issues in the study of change processes in psychotherapy. *Clinical Psychology Review, 27*(6), 682-695.

Lazaridou, A., Paschali, M., Schreiber, K., Galenkamp, L., Berry, M., Paschalis, T., Napadow, V., & Edwards, R. R. (2020). The association between daily physical exercise and pain among women with fibromyalgia: the moderating role of pain catastrophizing. *Pain Reports, 5*(4), e832. https://doi.org/10.1097/PR9.0000000000000832

Lazarus, R., & Folkman, S. (1984). *Stress, appraisal and coping*. Springer.

Lee, E. J., Wu, M. Y., Lee, G. K., Cheing, G., & Chan, F. (2008). Catastrophizing as a cognitive vulnerability factor related to depression in workers' compensation patients with

chronic musculoskeletal pain. *Journal of Clinical Psychology in Medical Settings, 15*(3), 182-192. https://doi.org/10.1007/s10880-008-9118-7

Liew, B. X. W., Scutari, M., Peolsson, A., Peterson, G., Ludvigsson, M. L., & Falla, D. (2019). Investigating the causal mechanisms of symptom recovery in chronic whiplash-associated disorders using Bayesian networks. *The Clinical Journal of Pain, 35*(8), 647-655. https://doi.org/10.1097/AJP.0000000000000728

Linton, S. J. (2013). A transdiagnostic approach to pain and emotion. *Journal of Applied Biobehavioral Research, 18*(2), 82-103.

Linton, S. J., & Bergbom, S. (2011). Understanding the link between depression and pain. *Scandinavian Journal of Pain, 2*(2), 47-54. https://doi.org/10.1016/j.sjpain.2011.01.005

Linton, S. J., Flink, I. K., Schrooten, M. G. S., & Wiksell, R. (2016). Understanding co-occurring emotion and pain: The role of context sensitivity from a transdiagnostic perspective. *Journal of Contemporary Psychotherapy, 46*(3), 129-137. https://doi.org/10.1007/s10879-016-9323-x

Linton, S. J., Flink, I. K., & Vlaeyen, J. W. S. (2018). Understanding the etiology of chronic pain from a psychological perspective. *Physical Therapy, 98*(5), 315-324.

Linton, S. J., Nicholas, M. K., MacDonald, S., Boersma, K., Bergbom, S., Maher, C., & Refshauge, K. (2011). The role of depression and catastrophizing in musculoskeletal pain. *European Journal of Pain, 15*(4), 416-422. https://doi.org/10.1016/j.ejpain.2010.08.009

Loggia, M. L., Berna, C., Kim, J., Cahalan, C. M., Martel, M. O., Gollub, R. L., Wasan, A. D., Napadow, V., & Edwards, R. R. (2015). The lateral prefrontal cortex mediates the hyperalgesic effects of negative cognitions in chronic pain patients. *The Journal of Pain, 16*(8), 692-699. https://doi.org/10.1016/j.jpain.2015.04.003

Lopez, M. N., Pierce, R. S., Gardner, R. D., & Hanson, R. W. (2013). Standardized Beck Depression Inventory-II scores for male veterans coping with chronic pain. *Psychological Services, 10*(2), 257-263. https://doi.org/10.1037/a0027920

Lopez-Martinez, A. E., Ramirez-Maestre, C., & Esteve, R. (2014). An examination of the structural link between post-traumatic stress symptoms and chronic pain in the framework of fear-avoidance models. *European Journal of Pain, 18*(8), 1129-1138. https://doi.org/10.1002/j.1532-2149.2014.00459.x

Luciano, J. V., Guallar, J. A., Aguado, J., Lopez-Del-Hoyo, Y., Olivan, B., Magallon, R., Alda, M., Serrano-Blanco, A., Gili, M., & Garcia-Campayo, J. (2014). Effectiveness of group acceptance and commitment therapy for fibromyalgia: a 6-month randomized

controlled trial (EFFIGACT study). *Pain, 155*(4), 693-702. https://doi.org/10.1016/j.pain.2013.12.029

Mankovsky, T., Lynch, M. E., Clark, A. J., Sawynok, J., & Sullivan, M. J. L. (2012). Pain catastrophizing predicts poor response to topical analgesics in patients with neuropathic pain. *Pain Research and Management, 17*(1), 10-14.

Mansell, W., Harvey, A., Watkins, E., & Shafran, R. (2009). Conceptual foundations of the transdiagnostic approach to CBT. *Journal of Cognitive Psychotherapy, 23*(1), 6-19. https://doi.org/10.1891/0889-8391.23.1.6

Martin, A. L., Halket, E., Asmundson, G. J., Flora, D. B., & Katz, J. (2010). Posttraumatic stress symptoms and the diathesis-stress model of chronic pain and disability in patients undergoing major surgery. *The Clinical Journal of Pain, 26*(6), 518-527. https://doi.org/10.1097/AJP.0b013e3181e15b98

McWilliams, L. A., Kowal, J., & Wilson, K. G. (2015). Development and evaluation of short forms of the Pain Catastrophizing Scale and the Pain Self-efficacy Questionnaire. *European Journal of Pain, 19*(9), 1342-1349. https://doi.org/10.1002/ejp.665

Meeus, M., Nijs, J., Van Oosterwijck, J., Van Alsenoy, V., & Truijen, S. (2010). Pain physiology education improves pain beliefs in patients with chronic fatigue syndrome compared with pacing and self-management education: a double-blind randomized controlled trial. *Archives of Physical Medicine and Rehabilitation, 91*(8), 1153-1159. https://doi.org/10.1016/j.apmr.2010.04.020

Michael, E. S., & Burns, J. W. (2004). Catastrophizing and pain sensitivity among chronic pain patients: moderating effects of sensory and affect focus. *Annals of Behavioral Medicine, 27*(3), 185-194. https://doi.org/10.1207/s15324796abm2703_6

Moeller-Bertram, T., Keltner, J., & Strigo, I. A. (2012). Pain and post traumatic stress disorder - review of clinical and experimental evidence. *Neuropharmacology, 62*(2), 586-597. https://doi.org/10.1016/j.neuropharm.2011.04.028

Moore, E., Adams, H., Ellis, T., Thibault, P., & Sullivan, M. J. L. (2018). Assessing catastrophic thinking associated with debilitating mental health conditions. *Disability and Rehabilitation, 40*(3), 317-322.

Moseley, G. L. (2007). Reconceptualising pain according to modern pain science. *Physical Therapy Reviews, 12*(3), 169-178. https://doi.org/10.1179/108331907x223010

Moseley, G. L., Nicholas, M. K., & Hodges, P. W. (2004). A randomized controlled trial of intensive neurophysiology education in chronic low back pain. *The Clinical Journal of Pain, 20*(5), 324-330.

Mouthaan, J., Sijbrandij, M., Reitsma, J. B., Gersons, B. P., & Olff, M. (2014). Comparing screening instruments to predict posttraumatic stress disorder. *PLOS One, 9*(5), e97183. https://doi.org/10.1371/journal.pone.0097183

Neville, A., Soltani, S., Pavlova, M., & Noel, M. (2018). Unravelling the relationship between parent and child PTSD and pediatric chronic pain: the mediating role of pain catastrophizing. *The Journal of Pain, 19*(2), 196-206. https://doi.org/10.1016/j.jpain.2017.10.004

Niederstrasser, N. G., Slepian, P. M., Mankovsky-Arnold, T., Lariviere, C., Vlaeyen, J. W., & Sullivan, M. J. (2014). An experimental approach to examining psychological contributions to multisite musculoskeletal pain. *The Journal of Pain, 15*(11), 1156-1165. https://doi.org/10.1016/j.jpain.2014.08.007

Nieto, R., Miro, J., Huguet, A., & Saldana, C. (2011). Are coping and catastrophising independently related to disability and depression in patients with whiplash associated disorders? *Disability and Rehabilitation, 33*(5), 389-398. https://doi.org/10.3109/09638288.2010.491576

Niska, R., Bhuiya, F., & Xu, J. (2010). National Hospital Ambulatory Medical Care Survey: 2007 Emergency Department Summary. *National Health Statistics Report*(26), 1-31.

Nordin, L., & Perrin, S. (2019). Pain and posttraumatic stress disorder in refugees who survived torture: The role of pain catastrophizing and trauma-related beliefs. *European Journal of Pain*. https://doi.org/10.1002/ejp.1415

O'Donnell, M. L., Lau, W., Chisholm, K., Agathos, J., Little, J., Terhaag, S., Brand, R., Putica, A., Holmes, A. C. N., Katona, L., Felmingham, K. L., Murray, K., Hosseiny, F., & Gallagher, M. W. (2021). A pilot study of the efficacy of the Unified Protocol for transdiagnostic treatment of emotional disorders in treating posttraumatic psychopathology: A randomized controlled trial. *Journal of Traumatic Stress, 34*(3), 563-574. https://doi.org/10.1002/jts.22650

Otero-Ketterer, E., Penacoba-Puente, C., Valera-Calero, J. A., Galan-Del-Rio, F., & Ortega-Santiago, R. (2023). Patient-reported outcome measurements (PROMs): Use during the physical therapy practice and associated factors. *Musculoskeletal Science & Practice, 64*, 102744. https://doi.org/10.1016/j.msksp.2023.102744

Overaas, C. K., Johansson, M. S., de Campos, T. F., Ferreira, M. L., Natvig, B., Mork, P. J., & Hartvigsen, J. (2017). Prevalence and pattern of co-occurring musculoskeletal pain and its association with back-related disability among people with persistent low back pain: protocol for a systematic review and meta-analysis. *Systematic Reviews, 6*(1), 258. https://doi.org/10.1186/s13643-017-0656-7

Paré, C., Thibault, P., Cote, P., Pimentel, S. D., Shen, S., Yakobov, E., & Sullivan, M. J. L. (2019). The relationship between level of catastrophizing and mental health comorbidity in individuals with whiplash injuries. *The Clinical Journal of Pain, 35*(11), 880-886. https://doi.org/10.1097/AJP.0000000000000749

Paunovic, N. (1998). Cognitive factors in the maintenance of PTSD. *Cognitive Behaviour Therapy, 27*(4), 167-178. https://doi.org/10.1080/02845719808408511

Petrini, L., & Arendt-Nielsen, L. (2020). Understanding pain catastrophizing: Putting pieces together. *Frontiers in Psychology, 11*, 603420. https://doi.org/10.3389/fpsyg.2020.603420

Picavet, H. S., Vlaeyen, J. W., & Schouten, J. S. (2002). Pain catastrophizing and kinesiophobia: predictors of chronic low back pain. *American Journal of Epidemiology, 156*(11), 1028-1034. https://doi.org/10.1093/aje/kwf136

Pink, J., Petrou, S., Williamson, E., Williams, M., & Lamb, S. E. (2016). Economic and health-related quality of life outcomes of whiplash associated disorders. *Spine, 41*(17), 1378-1386. https://doi.org/10.1097/BRS.0000000000001512

Quartana, P. J., Campbell, C. M., & Edwards, R. R. (2009). Pain catastrophizing: a critical review. *Expert Review of Neurotherapeutics, 9*(5), 745-758. https://doi.org/10.1586/ern.09.34

Quinlan, K. P., Annest, J. L., Myers, B., Ryan, G., & Hill, H. (2004). Neck strains and sprains among motor vehicle occupants-United States, 2000. *Accident Analysis and Prevention, 36*(1), 21-27. https://www.ncbi.nlm.nih.gov/pubmed/14572823

Racine, M., Moulin, D. E., Nielson, W. R., Morley-Forster, P. K., Lynch, M., Clark, A. J., Stitt, L., Gordon, A., Nathan, H., Smyth, C., Ware, M. A., & Jensen, M. P. (2016). The reciprocal associations between catastrophizing and pain outcomes in patients being treated for neuropathic pain: a cross-lagged panel analysis study. *Pain, 157*(9), 1946-1953. https://doi.org/10.1097/j.pain.0000000000000594

Ravn, S. L., Hartvigsen, J., Hansen, M., Sterling, M., & Andersen, T. E. (2018). Do post-traumatic pain and post-traumatic stress symptomatology mutually maintain each other? A systematic review of cross-lagged studies. *Pain, 159*(11), 2159-2169. https://doi.org/10.1097/j.pain.0000000000001331

Ravn, S. L., Karstoft, K. I., Sterling, M., & Andersen, T. E. (2019). Trajectories of posttraumatic stress symptoms after whiplash: A prospective cohort study. *European Journal of Pain, 23*(3), 515-525. https://doi.org/10.1002/ejp.1325

Rayner, L., Hotopf, M., Petkova, H., Matcham, F., Simpson, A., & McCracken, L. M. (2016). Depression in patients with chronic pain attending a specialised pain treatment centre: prevalence and impact on health care costs. *Pain, 157*(7), 1472-1479. https://doi.org/10.1097/j.pain.0000000000000542

Reinholt, N., Hvenegaard, M., Christensen, A. B., Eskildsen, A., Hjorthoj, C., Poulsen, S., Arendt, M. B., Rosenberg, N. K., Gryesten, J. R., Aharoni, R. N., Alro, A. J., Christensen, C. W., & Arnfred, S. M. (2022). Transdiagnostic versus diagnosis-specific group Cognitive Behavioral Therapy for anxiety disorders and depression: A randomized controlled trial. *Psychotherapy and Psychosomatics, 91*(1), 36-49. https://doi.org/10.1159/000516380

Rhudy, J. L., Martin, S. L., Terry, E. L., France, C. R., Bartley, E. J., DelVentura, J. L., & Kerr, K. L. (2011). Pain catastrophizing is related to temporal summation of pain but not temporal summation of the nociceptive flexion reflex. *Pain, 152*(4), 794-801. https://doi.org/10.1016/j.pain.2010.12.041

Ritchie, C., & Sterling, M. (2016). Recovery pathways and prognosis after whiplash injury. *The Journal of Orthopaedic and Sports Physical Therapy, 46*(10), 851-861. https://doi.org/10.2519/jospt.2016.6918

Roman, C., Cumsille, P., & Gomez-Perez, L. (2021). Pain intensity predicts pain catastrophizing during the postpartum period: A longitudinal random intercept cross-lagged panel study. *Pain Medicine, 22*(11), 2542-2549. https://doi.org/10.1093/pm/pnab144

Rosenstiel, A., & Keefe, F. (1983). The use of coping strategies in chronic low back pain patients: Relationship to patient characteristics and current adjustment. *Pain, 17*, 33-44.

Rosenstiel, A. K., & Roth, S. (1981). Relationship between cognitive activity and adjustment in four spinal-cord-injured individuals: a longitudinal investigation. *Journal of Human Stress, 7*(1), 35-43.

Ruscheweyh, R., Viehoff, A., Tio, J., & Pogatzki-Zahn, E. M. (2017). Psychophysical and psychological predictors of acute pain after breast surgery differ in patients with and without pre-existing chronic pain. *Pain, 158*(6), 1030-1038. https://doi.org/10.1097/j.pain.0000000000000873

Ryum, T., Hartmann, H., Borchgrevink, P., de Ridder, K., & Stiles, T. C. (2021). The effect of in-session exposure in Fear-Avoidance treatment of chronic low back pain: A randomized controlled trial. *European Journal of Pain, 25*(1), 171-188. https://doi.org/10.1002/ejp.1659

Sarrami, P., Armstrong, E., Naylor, J. M., & Harris, I. A. (2017). Factors predicting outcome in whiplash injury: a systematic meta-review of prognostic factors. *Journal of Orthopaedics and Traumatology, 18*(1), 9-16. https://doi.org/10.1007/s10195-016-0431-x

Schultz, Z. I., Crook, J., Meloche, R. G., Berkowitz, J., Milner, R., Zuberbier, A. O., & Meloche, W. (2004). Psychosocial factors predictive of occupational low back disability: towards development of a return-to-work model. *Pain, 107*(1), 77-85. https://doi.org/10.1016/j.pain.2003.09.019

Schutze, R., Rees, C., Slater, H., Smith, A., & O'Sullivan, P. (2017). 'I call it stinkin' thinkin'': A qualitative analysis of metacognition in people with chronic low back pain and elevated catastrophizing. *British Journal of Health Psychology, 22*(3), 463-480. https://doi.org/10.1111/bjhp.12240

Schutze, R., Rees, C., Smith, A., Slater, H., Campbell, J. M., & O'Sullivan, P. (2018). How can we best reduce pain catastrophizing in adults with chronic noncancer pain? A systematic review and meta-analysis. *The Journal of Pain, 19*(3), 233-256. https://doi.org/10.1016/j.jpain.2017.09.010

Scott, W., Wideman, T. H., & Sullivan, M. J. L. (2014). Clinically meaningful scores on pain catastrophizing before and after multidisciplinary rehabilitation - A prospective study of individuals with subacute pain after whiplash injury. *Clinical Journal of Pain, 30*(3), 183-190.

Selig, J. P., & Little, T. D. (2012). Autoregressive and cross-lagged panel analysis for longitudinal data. In *Handbook of Developmental Research Methods*. The Guilford Press.

Seligman, M. E. P., Allen, A. R., Vie, L. L., Ho, T. E., Scheier, L. M., Cornum, R., & Lester, P. B. (2019). PTSD - Catastrophizing in combat as risk and protection. *Clinical Psychological Science, 7*(3), 516-529.

Seminowicz, D. A., & Davis, K. D. (2006). Cortical responses to pain in healthy individuals depends on pain catastrophizing. *Pain, 120*(3), 297-306.

Severeijns, R., van den Hout, M. A., & Vlaeyen, J. W. (2005). The causal status of pain catastrophizing: an experimental test with healthy participants. *European Journal of Pain, 9*(3), 257-265. https://doi.org/10.1016/j.ejpain.2004.07.005

Sharp, T. J., & Harvey, A. G. (2001). Chronic pain and posttraumatic stress disorder: mutual maintenance? *Clinical Psychology Review, 21*(6), 857-877. https://doi.org/S0272-7358(00)00071-4 [pii]

Shih, R. A., Schell, T. L., Hambarsoomian, K., Belzberg, H., & Marshall, G. N. (2010, Dec). Prevalence of posttraumatic stress disorder and major depression after trauma center hospitalization. *The Journal of trauma, 69*(6), 1560-1566. https://doi.org/10.1097/TA.0b013e3181e59c05

Shim, E., Song, Y. W., Park, S. H., Lee, K. M., Go, D. J., & Hahm, B. J. (2017). Examining the relationship between pain catastrophizing and suicide risk in patients with rheumatic disease: the mediating role of depression, perceived social support, and perceived burdensomeness. *International Journal of Behavioral Medicine, 24*(4), 501-512. https://doi.org/10.1007/s12529-017-9648-1

Sleep, C. E., Lynam, D. R., & Miller, J. D. (2022). Understanding individuals' desire for change, perceptions of impairment, benefits, and barriers of change for pathological personality traits. *Personality Disorders: Theory, Research, and Treatment, 13*(3), 245-253. https://doi.org/10.1037/per0000501

Slepian, P., Bernier, E., Scott, W., Niederstrasser, N. G., Wideman, T., & Sullivan, M. (2014). Changes in pain catastrophizing following physical therapy for musculoskeletal injury: the influence of depressive and post-traumatic stress symptoms. *Journal of Occupational Rehabilitation, 24*(1), 22-31. https://doi.org/10.1007/s10926-013-9432-2

Smeets, R. J., Vlaeyen, J. W., Kester, A. D., & Knottnerus, J. A. (2006, Apr). Reduction of pain catastrophizing mediates the outcome of both physical and cognitive-behavioral treatment in chronic low back pain. *The journal of pain : official journal of the American Pain Society, 7*(4), 261-271. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=16618470

Smith, A. D., Jull, G., Schneider, G., Frizzell, B., Hooper, R. A., & Sterling, M. (2013). A comparison of physical and psychological features of responders and non-responders to cervical facet blocks in chronic whiplash. *BMC Musculoskeletal Disorders, 14*, 313. https://doi.org/10.1186/1471-2474-14-313

Son, C., Son, D., An, J., & Cho, S. (2019). Gender-dependent difference in the relationship between pain aspects and pain catastrophizing. *Social Behavior and Personality, 47*(2), 1-11. https://doi.org/10.2224/sbp.7718

Spanos, N. P., Radtke-Bodorik, H. L., Ferguson, J. D., & Jones, B. (1979). The effects of hypnotic susceptibility, suggestions for analgesia, and utilization of cognitive strategies on the reduction of pain. *Journal of Abnormal Psychology, 88*, 282 - 292.

Speed, T. J., Jung Mun, C., Smith, M. T., Khanuja, H. S., Sterling, R. S., Letzen, J. E., Haythornthwaite, J. A., Edwards, R. R., & Campbell, C. M. (2021). Temporal association of pain catastrophizing and pain severity across the perioperative period: A cross-lagged panel analysis after total knee arthroplasty. *Pain Medicine, 22*(8), 1727-1734. https://doi.org/10.1093/pm/pnab035

Spinhoven, P., Ter Kuile, M., Kole-Snijders, A. M., Hutten Mansfeld, M., Den Ouden, D. J., & Vlaeyen, J. W. (2004). Catastrophizing and internal pain control as mediators of outcome

in the multidisciplinary treatment of chronic low back pain. *European Journal of Pain, 8*(3), 211-219. https://doi.org/10.1016/j.ejpain.2003.08.003

Spitzer, W. O., Skovron, M. L., Salmi, L. R., Cassidy, J. D., Duranceau, J., Suissa, S., & Zeiss, E. (1995). Scientific monograph of the Quebec Task Force on Whiplash-Associated Disorders: redefining "whiplash" and its management. *Spine, 20*(8 Suppl), 1S-73S.

Staud, R., Craggs, J. G., Robinson, M. E., Perlstein, W. M., & Price, D. D. (2007). Brain activity related to temporal summation of C-fiber evoked pain. *Pain, 129*(1-2), 130-142. https://doi.org/10.1016/j.pain.2006.10.010

Sterling, M. (2011). Does knowledge of predictors of recovery and nonrecovery assist outcomes after whiplash injury? *Spine, 36*(25 Suppl), S257-262. https://doi.org/10.1097/BRS.0b013e31823881bc

Sterling, M. (2016). How do we prevent the transition from acute to chronic pain after whiplash injury? In *Whiplash injury: Perspectives on the development of chronic pain.* Wolters Kluwer.

Sullivan, M., Adams, H., Ellis, T., Clark, R., Sully, C., & Thibault, P. (2016). Treatment-related reductions in catastrophizing predict return to work in individuals with post-traumatic stress disorder. *Journal of Applied Biobehavioral Research, 22*(1). https://doi.org/10.1111/jabr.12087

Sullivan, M., Adams, H., Thibault, P., Moore, E., Carriere, J. S., & Lariviere, C. (2017). Return to work helps maintain treatment gains in the rehabilitation of whiplash injury. *Pain, 158*(5), 980-987. https://doi.org/10.1097/j.pain.0000000000000871

Sullivan, M. J. L. (2012). The communal coping model of pain catastrophising: Clinical and research implications. *Canadian Psychology, 53*(1), 32-41. https://doi.org/10.1037/a0026726

Sullivan, M. J. L., Adams, H., Horan, S., Maher, D., Boland, D., & Gross, R. (2008). The role of perceived injustice in the experience of chronic pain and disability: scale development and validation. *Journal of Occupational Rehabilitation, 18*(3), 249-261. https://doi.org/10.1007/s10926-008-9140-5

Sullivan, M. J. L., Adams, H., Martel, M. O., Scott, W., & Wideman, T. (2011). Catastrophizing and perceived injustice: risk factors for the transition to chronicity after whiplash injury. *Spine, 36*(25 Suppl), S244-249. https://doi.org/10.1097/BRS.0b013e3182387fed

Sullivan, M. J. L., Adams, H., Rhodenizer, T., & Stanish, W. D. (2006). A psychosocial risk factor--targeted intervention for the prevention of chronic pain and disability following whiplash injury. *Physical Therapy, 86*(1), 8-18.

Sullivan, M. J. L., Bishop, S., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment, 7*, 524-532.

Sullivan, M. J. L., & D'Eon, J. L. (1990). Relation between catastrophizing and depression in chronic pain patients. *Journal of Abnormal Psychology, 99*(3), 260-263.

Sullivan, M. J. L., Davidson, N., Garfinkiel, B., Siriapaipant, N., & Scott, W. (2009). Perceived injustice is associated with heightened pain behavior and disability in individuals with whiplash injuries. *Psychological Injury and Law, 2*, 238 - 247.

Sullivan, M. J. L., Donayre Pimentel, S., & Paré, C. (2020). Work and pain: A lifespan development approach. In E. Wainwright & C. Eccleston (Eds.). Oxford University Press.

Sullivan, M. J. L., Lariviere, C., & Simmonds, M. (2010). Activity-related summation of pain and functional disability in patients with whiplash injuries. *Pain, 151*(2), 440-446. https://doi.org/10.1016/j.pain.2010.08.005

Sullivan, M. J. L., Rodgers, W. M., & Kirsch, I. (2001). Catastrophizing, depression and expectancies for pain and emotional distress. *Pain, 91*(1-2), 147-154.

Sullivan, M. J. L., Rouse, D., Bishop, S. R., & Johnston, S. (1997). Thought suppression, catastrophizing and pain. *Cognitive Therapy and Research, 21*, 555 - 568.

Sullivan, M. J. L., Simmonds, M., & Velly, A. (2006). *Pain, Depression, Disability and Rehabilitation Outcomes*. Institut de recherche Robert-Sauvé en santé et en sécurité de travail.

Sullivan, M. J. L., Stanish, W., Waite, H., Sullivan, M., & Tripp, D. A. (1998). Catastrophizing, pain, and disability in patients with soft-tissue injuries. *Pain, 77*(3), 253-260.

Sullivan, M. J. L., & Stanish, W. D. (2003). Psychologically-based occupational rehabilitation: the Pain-Disability Prevention Program. *The Clinical Journal of Pain, 19*(2), 97-104.

Sullivan, M. J. L., Thibault, P., Simmonds, M. J., Milioto, M., Cantin, A. P., & Velly, A. M. (2009). Pain, perceived injustice and the persistence of post-traumatic stress symptoms during the course of rehabilitation for whiplash injuries. *Pain, 145*(3), 325-331. https://doi.org/S0304-3959(09)00380-7

Sullivan, M. J. L., Thorn, B., Haythornthwaite, J. A., Keefe, F., Martin, M., Bradley, L. A., & Lefebvre, J. C. (2001). Theoretical perspectives on the relation between catastrophizing and pain. *The Clinical Journal of Pain, 17*(1), 52-64.

Sullivan, M. J. L., Ward, L. C., Tripp, D., French, D. J., Adams, H., & Stanish, W. D. (2005). Secondary prevention of work disability: Community-based psychosocial intervention for musculoskeletal disorders. *Journal of Occupational Rehabilitation, 15*(3), 377-392. https://doi.org/10.1007/s10926-005-5944-7

Thombs, B. D., Kwakkenbos, L., Levis, A. W., & Benedetti, A. (2018). Addressing overestimation of the prevalence of depression based on self-report screening questionnaires. *CMAJ, 190*(2), E44-E49. https://doi.org/10.1503/cmaj.170691

Thompson, D. P., Oldham, J. A., Urmston, M., & Woby, S. R. (2010). Cognitive determinants of pain and disability in patients with chronic whiplash-associated disorder: a cross-sectional observational study. *Physiotherapy, 96*(2), 151-159. https://doi.org/10.1016/j.physio.2009.11.001

Thorn, B. E. (2017). *Cognitive Therapy for Chronic Pain: A Step-by-Step Guide* (2nd ed.). The Guilford Press.

Thorn, B. E., & Burns, J. W. (2011). Common and specific treatment mechanisms in psychosocial pain interventions: the need for a new research agenda. *Pain, 152*(4), 705-706. https://doi.org/10.1016/j.pain.2010.12.017

Titov, N., Dear, B. F., Schwencke, G., Andrews, G., Johnston, L., Craske, M. G., & McEvoy, P. (2011). Transdiagnostic internet treatment for anxiety and depression: a randomised controlled trial. *Behavior Research and Therapy, 49*(8), 441-452. https://doi.org/10.1016/j.brat.2011.03.007

Trost, Z., Strachan, E., Sullivan, M., Vervoort, T., Avery, A. R., & Afari, N. (2015). Heritability of pain catastrophizing and associations with experimental pain outcomes: a twin study. *Pain, 156*(3), 514-520. https://doi.org/10.1097/01.j.pain.0000460326.02891.fc

Tsur, N., Defrin, R., & Ginzburg, K. (2017). Posttraumatic stress disorder, orientation to pain, and pain perception in ex-prisoners of war who underwent torture. *Psychosomatic Medicine, 79*(6), 655-663. https://doi.org/10.1097/PSY.0000000000000461

Turk, D. C., Robinson, J. P., & Duckworth, M. P. (2018). The impact of psychosocial and contextual factors on individuals who sustain whiplash-associated disorders in motor vehicle collisions. *Psychological Injury and Law, 11*(3), 218-232. https://doi.org/10.1007/s12207-018-9317-y

Turk, D. C., Rudy, T., & Salovey, P. (1985). The McGill Pain Questionnaire: Confirming the factor analysis and examining appropriate uses. *Pain, 21*, 385-397.

Turner, J. A., & Aaron, L. A. (2001). Pain-related catastrophizing: what is it? *The Clinical Journal of Pain, 17*(1), 65-71. http://www.ncbi.nlm.nih.gov/pubmed/11289090

Turner, J. A., Anderson, M. L., Balderson, B. H., Cook, A. J., Sherman, K. J., & Cherkin, D. C. (2016). Mindfulness-based stress reduction and cognitive behavioral therapy for chronic low back pain: similar effects on mindfulness, catastrophizing, self-efficacy, and acceptance in a randomized controlled trial. *Pain, 157*(11), 2434-2444. https://doi.org/10.1097/j.pain.0000000000000635

Turner, J. A., Holtzman, S., & Mancl, L. (2007). Mediators, moderators, and predictors of therapeutic change in cognitive-behavioral therapy for chronic pain. *Pain, 127*(3), 276-286. https://doi.org/10.1016/j.pain.2006.09.005

Turner, J. A., Mancl, L., & Aaron, L. A. (2006). Short- and long-term efficacy of brief cognitive-behavioral therapy for patients with chronic temporomandibular disorder pain: a randomized, controlled trial. *Pain, 121*(3), 181-194. https://doi.org/10.1016/j.pain.2005.11.017

Vaegter, H. B., Andersen, T. E., Harvold, M., Andersen, P. G., & Graven-Nielsen, T. (2017). Increased pain sensitivity in accident-related chronic pain patients with comorbid posttraumatic stress. *The Clinical Journal of Pain*. https://doi.org/10.1097/AJP.0000000000000543

Van Damme, S., Crombez, G., & Eccleston, C. (2002). Retarded disengagement from pain cues: the effects of pain catastrophizing and pain expectancy. *Pain, 100*(1-2), 111-118. https://doi.org/S0304395902002907

Van Loey, N. E., Klein-Konig, I., de Jong, A. E. E., Hofland, H. W. C., Vandermeulen, E., & Engelhard, I. M. (2018). Catastrophizing, pain and traumatic stress symptoms following burns: A prospective study. *European Journal of Pain, 22*(6), 1151-1159. https://doi.org/10.1002/ejp.1203

Vangronsveld, K. L., Peters, M., Goossens, M., & Vlaeyen, J. (2009). The influence of fear of movement and pain catastrophizing on daily pain and disability in individuals with acute whiplash injury: a daily diary study. *Pain, 139*(2), 449-457. https://doi.org/10.1016/j.pain.2008.05.019

Vargas-Prada, S., & Coggon, D. (2015). Psychological and psychosocial determinants of musculoskeletal pain and associated disability. *Best Practice & Research Clinical Rheumatology, 29*(3), 374-390. https://doi.org/10.1016/j.berh.2015.03.003

Varkovitzky, R. L., Sherrill, A. M., & Reger, G. M. (2017). Effectiveness of the Unified Protocol for Transdiagnostic Treatment of Emotional Disorders among veterans with Posttraumatic Stress Disorder - A pilot study. *Behavior Modification, 42*(2), 210-230.

Vervoort, T., Trost, Z., Prkachin, K. M., & Mueller, S. C. (2013). Attentional processing of other's facial display of pain: an eye tracking study. *Pain, 154*(6), 836-844. https://doi.org/10.1016/j.pain.2013.02.017

Vlaeyen, J. W., & Linton, S. J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: a state of the art. *Pain, 85*(3), 317-332.

Vowles, K. E., Gross, R. T., & Sorrell, J. T. (2004). Predicting work status following interdisciplinary treatment for chronic pain. *European Journal of Pain, 8*(4), 351-358. https://doi.org/10.1016/j.ejpain.2003.10.009

Vowles, K. E., McCracken, L. M., & Eccleston, C. (2007). Processes of change in treatment for chronic pain: the contributions of pain, acceptance, and catastrophizing. *European Journal of Pain, 11*(7), 779-787. https://doi.org/10.1016/j.ejpain.2006.12.007

Vowles, K. E., & Sorrell, J. T. (2008). *Life with Chronic Pain - An Acceptance-Based Approach.*

Walton, D. M., & Elliott, J. M. (2017). An integrated model of chronic whiplash-associated disorder. *The Journal of Orthopaedic and Sports Physical Therapy, 47*(7), 462-471. https://doi.org/10.2519/jospt.2017.7455

Walton, D. M., Macdermid, J. C., Giorgianni, A. A., Mascarenhas, J. C., West, S. C., & Zammit, C. A. (2013). Risk factors for persistent problems following acute whiplash injury: update of a systematic review and meta-analysis. *The Journal of Orthopaedic and Sports Physical Therapy, 43*(2), 31-43. https://doi.org/10.2519/jospt.2013.4507

Walton, D. M., Mehta, S., Seo, W., & MacDermid, J. C. (2020). Creation and validation of the 4-item BriefPCS-chronic through methodological triangulation. *Health and Quality of Life Outcomes, 18*(1), 124. https://doi.org/10.1186/s12955-020-01346-8

Weiss, D., & Marmar, C. (1997). The Impact of Events Scale - Revised. In J. Wilson & T. Keane (Eds.), *Assessing Psychological Trauma and PTSD* (pp. 399-411). Guilford.

Weissman-Fogel, I., Sprecher, E., & Pud, D. (2008). Effects of catastrophizing on pain perception and pain modulation. *Experimental Brain Research, 186*(1), 79-85. https://doi.org/10.1007/s00221-007-1206-7

Wheeler, C. H. B., Williams, A. C. C., & Morley, S. J. (2019). Meta-analysis of the psychometric properties of the Pain Catastrophizing Scale and associations with participant characteristics. *Pain, 160*(9), 1946-1953. https://doi.org/10.1097/j.pain.0000000000001494

Wideman, T. H., Finan, P. H., Edwards, R. R., Quartana, P. J., Buenaver, L. F., Haythornthwaite, J. A., & Smith, M. T. (2014). Increased sensitivity to physical activity among individuals

with knee osteoarthritis: relation to pain outcomes, psychological factors, and responses to quantitative sensory testing. *Pain, 155*(4), 703-711. https://doi.org/10.1016/j.pain.2013.12.028

Wideman, T. H., & Sullivan, M. J. L. (2011). Reducing catastrophic thinking associated with pain. *Pain Manag, 1*, 249 - 256.

Williams, A. C., Eccleston, C., & Morley, S. (2012). Psychological therapies for the management of chronic pain (excluding headache) in adults. *Cochrane Database of Systematic Reviews, 11*, CD007407. https://doi.org/10.1002/14651858.CD007407.pub3

Yarnitsky, D. (2010). Conditioned pain modulation (the diffuse noxious inhibitory control-like effect): its relevance for acute and chronic pain states. *Current Opinion in Anaesthesiology, 23*(5), 611-615. https://doi.org/10.1097/ACO.0b013e32833c348b

Yarnitsky, D., Crispel, Y., Eisenberg, E., Granovsky, Y., Ben-Nun, A., Sprecher, E., Best, L. A., & Granot, M. (2008). Prediction of chronic post-operative pain: pre-operative DNIC testing identifies patients at risk. *Pain, 138*(1), 22-28. https://doi.org/10.1016/j.pain.2007.10.033

Zhaoyang, R., Martire, L. M., & Darnall, B. D. (2020). Daily pain catastrophizing predicts less physical activity and more sedentary behavior in older adults with osteoarthritis. *Pain, 161*(11), 2603-2610. https://doi.org/10.1097/j.pain.0000000000001959

Ziadni, M. S., Gonzalez-Castro, L., Anderson, S., Krishnamurthy, P., & Darnall, B. D. (2021). Efficacy of a single-session "Empowered Relief" Zoom-delivered group intervention for chronic pain: Randomized controlled trial conducted during the COVID-19 pandemic. *Journal of Medical Internet Research, 23*(9), e29672. https://doi.org/10.2196/29672

Zweig, M. H., & Campbell, G. (1993). Receiver-Operating Characteristic (ROC) Plots: A Fundamental Evaluation Tool in Clinical Medicine. *Clinical Chemistry, 39*(4), 561-577.