



Mechanisms of heightened pain-related disability in Canadian Armed Forces members and Veterans with comorbid chronic pain and PTSD

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ABSTRACT

Introduction: Posttraumatic stress disorder (PTSD) is highly comorbid with chronic pain in military personnel. Individuals with both conditions experience higher pain-related disability. The mechanisms contributing to increased pain-related disability in Canadian Armed Forces (CAF) members and Veterans with comorbid chronic pain and PTSD are poorly understood. Thus, this study examined the role of two potential mechanisms of comorbid PTSD and chronic pain that contribute to pain-related disability in military personnel: sensitivity to pain traumatization (i.e., the propensity of an individual to develop a traumatic stress-like reaction to pain [SPT]) and catastrophic thinking about pain. **Methods:** Study participants were 165 CAF members and Veterans with chronic pain. Participants completed an online survey assessing PTSD status, chronic pain status, and questionnaires assessing SPT, pain catastrophizing, and pain-related disability. A parallel multiple mediation analysis investigated whether SPT and pain catastrophizing mediated the relationship between PTSD and pain-related disability. **Results:** CAF members and Veterans with comorbid chronic pain and PTSD reported significantly greater pain-related disability compared to participants with chronic pain only. Both SPT and pain catastrophizing significantly mediated the relationship between PTSD and pain-related disability. **Discussion:** Findings suggest that PTSD may lead to greater pain-related disability in individuals with chronic pain by increasing individuals' susceptibility to becoming traumatized by their pain and by increasing their tendency to engage in catastrophic thinking about their pain. Targeting SPT and pain catastrophizing in the treatment of patients with comorbid PTSD and chronic pain may be an effective treatment strategy for reducing pain-related disability in patients.

Key words: CAF, Canadian Armed Forces, chronic pain, pain catastrophizing, pain-related disability, posttraumatic stress disorder, PTSD, sensitivity to pain traumatization, Veterans

RÉSUMÉ

Introduction : Le trouble de stress post-traumatique (TSPT) est hautement associé à la douleur chronique au sein du personnel militaire. Les personnes qui présentent les deux affections éprouvent plus d'incapacités liées à la douleur. Les mécanismes qui contribuent à ces incapacités accrues chez les militaires et les Vétérán(e)s des Forces armées canadiennes (FAC) sont mal compris. C'est pourquoi les chercheur(se)s ont examiné le rôle de deux mécanismes potentiels du TSPT associé à la douleur chronique qui contribuent aux incapacités liées à la douleur au sein du personnel militaire : la sensibilité à la traumatisation de la douleur (la propension à acquérir une réaction traumatique analogue au stress face à la douleur [RSD]) et les pensées catastrophiques au sujet de la douleur. **Méthodologie :** Au total, 165 militaires et Vétérán(e)s des FAC atteints de douleur chronique ont participé à l'étude. Ces personnes ont rempli un sondage en ligne évaluant l'état de leur TSPT et l'état de leur douleur chronique, et des questionnaires évaluant leur RSD, leur catastrophisation de la douleur et leur incapacité liée à la douleur. Une analyse de médiation multiple parallèle a évalué si la RSD et la catastrophisation de la douleur catalysaient le lien entre le TSPT et l'incapacité liée à la douleur. **Résultats :** Les militaires et les Vétérán(e)s des FAC atteints de douleur chronique concomitante et de TSPT ont déclaré une incapacité liée à la douleur beaucoup plus élevée que ceux qui ne souffraient que de douleur chronique. La RSD et la catastrophisation de la douleur catalysaient toutes deux considérablement le lien entre le TSPT et l'incapacité liée à la douleur. **Discussion :** Selon les observations, le TSPT peut entraîner une plus grande incapacité liée à la douleur chez les personnes atteintes

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de douleur chronique, car elle accroît leur susceptibilité à devenir traumatisées par la douleur et leur tendance à entretenir des pensées catastrophiques au sujet de leur douleur. Le fait de cibler la RSD et la catastrophisation de la douleur pour le traitement des patient(e)s ayant un TSPT associé à la douleur chronique peut être une stratégie thérapeutique efficace pour réduire les incapacités liées à la douleur.

Mots-clés : catastrophisation de la douleur, douleur chronique, FAC, Forces armées canadiennes, incapacité liée à la douleur, sensibilité à la traumatisation de la douleur, trouble de stress post-traumatique, TSPT, Vétéran(e)s

LAY SUMMARY

Canadian Armed Forces (CAF) members and Veterans with chronic pain and posttraumatic stress disorder (PTSD) symptoms were surveyed. Participants with a high number of PTSD symptoms had a higher vulnerability to becoming psychologically traumatized by their chronic pain than participants with a low number of PTSD symptoms. In turn, participants with this high vulnerability reported experiencing more disability from their chronic pain than participants with a low vulnerability. In addition, participants with a high number of PTSD symptoms tended to have many catastrophic thoughts about their pain. In turn, these participants reported experiencing more disability from their chronic pain than participants with few catastrophic thoughts about their pain. PTSD may lead servicemembers and Veterans to experience high disability from their chronic pain by increasing how traumatized they feel by their pain and by increasing the number of catastrophic thoughts they have about their pain. Targeting pain-related psychological trauma symptoms and catastrophic thoughts when treating servicemembers and Veterans with chronic pain and PTSD may be effective at reducing disability from chronic pain.

INTRODUCTION

Due to the dangerous and physically demanding nature of their work, including exposure to traumatic stressors, military personnel are at an increased risk of developing posttraumatic stress disorder (PTSD) and chronic pain compared to the general population. While previous work estimated the point prevalence of chronic pain to be 18.9% in Canadian adults,¹ the point prevalence of chronic pain was 40.9% in Thompson et al.'s² study of Canadian Armed Forces (CAF) Veterans. Thompson et al.² also found PTSD was present in 11% of those surveyed, while Van Ameringen's³ epidemiological study revealed 2.4% of the Canadian population had PTSD.

Beyond the increased risk of developing either PTSD or chronic pain, previous research showed military personnel also demonstrate an elevated comorbidity between PTSD and chronic pain.⁴ For instance, in a study examining the prevalence of chronic pain and associated mental health factors in CAF Regular Force Veterans, 93% of Veterans with PTSD also reported chronic pain.⁵ The co-occurrence of PTSD and chronic pain is often associated with affective distress and physical disability. Evidence suggests the two conditions may interact in a way that negatively affects the course of both disorders.⁶ For instance, individuals with fibromyalgia who also had clinically significant levels of PTSD-like symptoms reported significantly greater pain, distress, life interference, and pain-related disability (i.e., the extent to which an individual's chronic pain interferes with their ability to complete home responsibilities,

occupational duties, and social activities),⁷ than individuals with fibromyalgia but without clinically significant PTSD-like symptoms.⁸ Similarly, higher PTSD symptoms were associated with worse health-related quality of life and greater pain complaints in youth with chronic pain.⁹ Therefore, it is possible military personnel with comorbid PTSD and chronic pain experience greater impairments and pain-related disability than personnel with chronic pain only.

While military personnel with comorbid PTSD and chronic pain may experience greater pain-related disability compared to personnel with chronic pain only, little is known about the mechanisms that contribute to greater disability in those with both conditions. To improve treatment outcomes in pain-related disability for CAF members and Veterans with comorbid PTSD and chronic pain, a better understanding of these mechanisms is needed. Evidence suggests cognitive and affective factors intrinsic to both PTSD and chronic pain, such as catastrophic cognitions and pain traumatization sensitivity, may maintain or exacerbate both conditions.^{10,11} Given the ability to exacerbate each condition, it is possible these factors may have additive or synergistic effects on pain-related disability in individuals with comorbid PTSD and chronic pain.

Sensitivity to pain traumatization (SPT), one such proposed factor, refers to the anxiety-related cognitive, emotional, and behavioural reactions to pain that resemble the features of a traumatic stress reaction.¹² SPT measures an individual's propensity to experience a traumatic stress-like response to pain. Military

personnel with PTSD may be more susceptible to experiencing a traumatic stress-like reaction to chronic pain than individuals without PTSD; such a reaction may lead to increased pain-related disability. Kleiman et al.'s¹¹ finding of a strong positive correlation between SPT scores and scores on the Posttraumatic Stress Disorder Checklist-Civilian Version (PCL-C) supports this notion. Symptoms of PTSD may contribute to higher levels of pain catastrophizing, the psychological propensity of an individual to ruminate, magnify, and feel helpless in the face of pain.¹³ Higher levels of catastrophic thinking about pain may lead to increased pain-related disability. This may be especially so given that previous studies demonstrated a deleterious relationship between catastrophic thinking about pain and pain-related disability.¹⁴⁻¹⁶

Given these two potential underlying mechanisms of increased pain-related disability in comorbid chronic pain and PTSD, this study first aimed to investigate whether CAF members and Veterans with comorbid chronic pain and PTSD experienced significantly greater pain-related disability compared to CAF members and Veterans with chronic pain only. The authors hypothesized participants with comorbid chronic pain and PTSD would have significantly greater pain-related disability compared to those with chronic pain but no PTSD.

Second, the study aimed to examine the role of SPT and pain catastrophizing in contributing to pain-related disability in servicemembers and Veterans. Taken together, there is evidence supporting the possibility that differences in pain-related disability in those with comorbid chronic pain and PTSD compared to those with chronic pain only may be due to the mediating effects of SPT and pain catastrophizing. The authors hypothesized participants with PTSD would report higher SPT and pain catastrophizing scores than participants who do not have PTSD. Similarly, the authors expected that SPT and pain catastrophizing would significantly and independently mediate the relationship between PTSD presence and pain-related disability. Such findings would identify potential treatment strategies for those with comorbid chronic pain and PTSD. For example, if severity of pain-related disability is mediated by SPT or pain catastrophizing, this may indicate treatment strategies focusing on SPT reduction and pain decatastrophization may reduce chronic pain disability and improve quality of life in military personnel.

METHODS

Participants were recruited by the Pain, Affect, and Cognition (PAC) Laboratory at Queen's University in Kingston, Ontario, Canada, for an online survey examining the contribution of PTSD symptomatology to the establishment and maintenance of chronic pain. Survey data were collected between January 2020 and January 2021.

Participants

Active CAF members (Regular Force, Reserve Force, or on leave) and Veterans were screened for this study (N = 232). To be included in the sample, participants were required to report experiencing chronic pain, defined as pain persisting for greater than three months¹⁷ and enduring after the injury or disease that initiated the pain experience had healed or resolved.¹⁸ The final sample consisted of 165 CAF members or Veterans with chronic pain (mean age = 50.96 years, SD = 11.08, 35 females).

Procedure

The study was approved by the Queen's University Health Sciences & Affiliated Teaching Hospitals Research Ethics Board. Participants were recruited via print advertisements posted in clinical delivery units where CAF members receive treatment, and in the *Canadian Military Family Magazine*, via online military forums (e.g., CAF Facebook groups), and through the Chronic Pain Centre of Excellence for Canadian Veterans listserv. Individuals interested in participating in the study were instructed to contact the PAC Laboratory at Queen's University via email. Eligible participants were then directed to the online survey via a secure survey link sent through email. Participants were required to read the Letter of Information describing the study purpose, procedure, and measures taken to protect participant confidentiality.

Informed consent was obtained prior to participants completing the survey. Participants then completed the survey, which consisted of a series of questionnaires and socio-demographic and military status questions. The survey took 45 minutes to one hour to complete. After completion, participants were presented with a downloadable debriefing form containing more information about the study's purpose and mental health resources (e.g., the CAF Member Assistance Program contact information), should any participants feel distressed after completing the survey.

Measures

Socio-demographic and military status

The online survey assessed socio-demographic information including age, gender, culture, country of current residence, relationship status, education level, and income. The survey also included questions assessing military status, including Regular or Reserve Force status, rank group, military branch, and deployment history.

Chronic pain status

Pain persisting after initial injury or disease has healed or resolved, and that lasts for greater than three months, is considered chronic.^{17,18} Participants were included if they indicated they received a diagnosis of chronic pain by a health professional, or if they experience persistent pain not diagnosed by a health professional, but persisting after the injury or disease that caused the pain healed or resolved and lasting for longer than three months.

PTSD status

Participants completed the PTSD Checklist for *DSM-5* (PCL-5) to assess PTSD symptoms and overall symptom severity.¹⁹ The PCL-5 includes 20 questions assessing the PTSD symptoms of intrusion, avoidance, negative alterations in cognitions and mood, and alterations in arousal and reactivity associated with a traumatic event. Respondents indicate how much they have been bothered by each symptom in the past month on a scale of 0 (not at all) to 4 (6 or more times a week/severe). Total PTSD symptom severity on the PCL-5 was calculated for each participant by totaling scores from each of the 20 questions. Previous research reported that total symptom severity scores of 31 to 33 on the PCL-5 are highly predictive of a PTSD diagnosis in Veterans.²⁰ The PCL-5 has satisfactory internal consistency, test-retest reliability, and aspects of convergent validity.¹⁹

Responses to the PCL-5 were also assessed according to the PTSD symptom cluster criteria outlined in the *DSM-5* to ensure participants categorized as having PTSD had also endorsed the minimum number of clinically significant symptoms from each symptom cluster in the *DSM-5* required for a *DSM-5* diagnosis of PTSD. A symptom was considered clinically significant if the participant indicated a score of 2 or greater for that symptom on the PCL-5.²¹ Therefore, participants were considered to have PTSD if they had total scores greater than 31 on the PCL-5 and reported the minimum number of clinically significant symptoms (with scores of 2 or more) from each symptom cluster required for a diagnosis of PTSD per *DSM-5* criteria.²²

Sensitivity to pain traumatization

Participants' sensitivity to pain traumatization was measured using the Sensitivity to Pain Traumatization Scale (SPTS-12), which includes 12 statements that describe beliefs, thoughts, feelings, and actions people have or do when in physical pain.¹² Participants indicated how true each statement was on a scale of 0 (not at all true) to 4 (entirely true). A total measure of SPT was calculated for each participant by totaling scores from each of the 12 questions. The SPTS-12 demonstrated good to very good reliability and validity, and moderate convergent and discriminant validity.¹²

Pain catastrophizing

Participants' tendency to ruminate, magnify, and feel helpless about their pain was assessed using the Pain Catastrophizing Scale (PCS).¹³ The PCS includes 13 statements describing different thoughts and feelings that may be associated with pain. Participants indicated the degree to which they have these thoughts and feelings while experiencing pain, on a scale of 0 (not at all) to 4 (all the time). Total pain catastrophizing score was calculated for each participant by totaling responses from each of the 13 questions. The PCS has shown good reliability and validity.¹³

Pain-related disability

Pain-related disability, the degree to which chronic pain interfered with participants' ability to engage in different life activities,²³ was measured using the Pain Disability Index (PDI).²³ The PDI includes seven categories of life activity (family/home responsibilities, recreation, social activity, occupation, sexual behaviour, self-care, and life support activity). Participants indicated the level of disability typically experienced on a scale of 0 (no disability) to 10 (total disability). Total pain-related disability was calculated by totaling scores from each of the seven questions. The PDI has shown reliability and validity.²⁴

Analyses

Data were analyzed using IBM SPSS Statistics Version 27. An independent-samples *t*-test was conducted to determine whether participants with comorbid PTSD and chronic pain had significantly more pain-related disability (as measured by PDI total score) than participants with chronic pain who did not have PTSD. To determine whether there were socio-demographic differences (i.e., sex assigned at birth, military status, and military rank) between participants with chronic pain

who had PTSD and those who did not have PTSD, χ^2 tests of independence were employed. An independent-samples *t*-test examined whether there were age differences between participants with chronic pain who had PTSD and those who did not have PTSD. Independent-samples *t*-tests were also conducted to examine whether participants with chronic pain who had PTSD and those who did not have PTSD significantly differed in SPT and pain catastrophizing severity. For each of the independent-samples *t*-tests, the assumption of normality of the distribution of the dependent variable was tested by visually assessing normal quantile-quantile (Q-Q) plots and by employing a Kolmogorov-Smirnov test. Homogeneity of variance was tested using Levene's test.

To determine whether SPT and pain catastrophizing significantly mediated the relationship between PTSD presence and pain-related disability in participants with chronic pain, SPT and pain catastrophizing were employed as mediators in a parallel mediation analysis using the PROCESS macro.²⁵ This parallel mediation model allowed for simultaneous tests of the effects of both variables on the relationship between PTSD and pain-related disability, while accounting for any association between them. Using parallel mediation is advantageous given that previous research suggests that SPT and pain catastrophizing are theoretically and statistically related, and that SPT may be a higher-order factor overlying pain catastrophizing.^{11,12} Inputting both psychological factors into one mediation model allowed comparison of the two theoretical factors to determine whether both significantly and separately mediate the relationship between PTSD presence and pain-related disability, or whether the relationship is significantly mediated through SPT only. Because 16 statistical analyses were conducted in the study (including the mediation model and tests of normality and homogeneity of variance), the authors applied a Bonferroni correction for multiple comparisons to each statistical analysis. This means the threshold for statistical significance was set to $\alpha = 0.003$ (i.e., $0.05/16$) for each statistical analysis.

Multicollinearity between SPT and pain catastrophizing scores was assessed using variance inflation factor (VIF) and condition indices. The mediation analysis used Hayes'²⁵(p. 585) model number 4 (mediation model), and significance was evaluated using bootstrap estimations for 10,000 samples and 95% confidence intervals. Standardized coefficients were reported for each mediation analysis. For the mediation analysis,

PDI residuals were assessed for normality, homoscedasticity, and linearity.

RESULTS

Descriptive statistics

Mean age of participants was 51.0 years (SD = 11.1, range = 24-81). The majority were white/Caucasian (80.6%). Regarding sex assigned at birth, 129 participants were male (78.2%) and 36 were female (21.8%). See Table 1 and 2 for socio-demographic characteristics of the sample. A description of the sample's military status and characteristics can be found in Table 3. Tables 4 and 5 depict descriptive characteristics of participants' pain. Of the 165 participants, 127 were CAF Veterans (77.0%), and 38 were current CAF members (23.0%). Of all participants, 101 (61.2%) met study criteria for PTSD, while 64 (38.8%) did not.

PTSD and pain-related disability

An independent-samples *t*-test was conducted to evaluate whether severity of pain-related disability in CAF members with chronic pain differed between those who had PTSD and those who did not. Q-Q plot analysis revealed PDI scores were normally distributed. A Kolmogorov-Smirnov test confirmed PDI scores followed a normal distribution, $D_{159} = 0.09$, $p = 0.006$, and a Levene's test confirmed variances were equal for participants with, and without PTSD, $F_{1,157} = 0.01$, $p = 0.92$. Pain-related disability of participants with PTSD (mean = 42.57, SD = 13.23) was significantly higher than participants without PTSD (mean = 32.98, SD = 13.27), $t_{157} = 4.47$, Cohen's $d = 0.72$, $p < 0.001$, 95% CI, 13.83-5.35.

Additional analyses were conducted to examine whether socio-demographic characteristics may account for the significant relationship found between PTSD status and pain-related disability. A χ^2 test of independence showed there was no significant association between sex and PTSD status, $\chi^2 (1, N = 165) = 2.35$, $\Phi = 0.12$, $p = 0.12$. Similarly, there was no significant association between service status (i.e., serving member or Veteran) and PTSD status, $\chi^2 (1, N = 165) = 0.01$, $\Phi = 0.01$, $p = 0.92$. There was no significant association between military rank (i.e., junior non-commissioned member, senior non-commissioned member, junior officer, or senior officer) and PTSD status, $\chi^2 (3, N = 164) = 0.88$, $\Phi = 0.07$, $p = 0.83$.

An independent-samples *t*-test was conducted to evaluate whether mean age of CAF personnel with

chronic pain differed between those who had PTSD and those who did not. The output of the Q-Q Plot revealed data for age were normally distributed, and normality was confirmed by a Kolmogorov-Smirnov

Table 1. Socio-demographic characteristics as a percentage of the sample

Characteristic	Percentage	Number
Age (in years)		
18-29	1.2	2
30-39	15.2	25
40-49	26.1	43
50-59	34.5	57
60+	23.0	38
Gender		
Male or primarily masculine	77.0	127
Female or primarily feminine	21.2	35
Non-binary	1.8	3
Culture		
Asian	1.2	2
Latin/South American	1.8	3
Caribbean	1.2	2
White/Caucasian	80.6	133
Indigenous	3.0	5
Middle Eastern	0.6	1
Other	11.5	19
Country of current residence		
Canada	98.8	163
United States	0.6	1
Australia	0.6	1
Relationship status		
Single	9.1	15
In a relationship	70.3	116
Other	20.6	34
Education level completed		
Less than high school	2.4	4
High school or GED	15.2	25
Trade certificate or diploma	14.5	24
College or other non-university certificate or diploma	21.8	36
Some university completed	15.8	26
Bachelor's degree	14.5	24
Some graduate or professional school completed after bachelor's degree	3.6	6
University degree, diploma, or certificate above the bachelor's level	12.1	20
Income		
less than CAD\$25,000	1.2	2
CAD\$25,001-CAD\$50,000	11.5	19
CAD\$50,001-CAD\$75,000	35.8	59
CAD\$75,001-CAD\$100,000	26.1	43
CAD\$100,001 or greater	21.8	36
Did not disclose	3.6	6

GED = General educational development.

test, $D_{159} = 0.05$, $p = 0.20$. A Levene's test confirmed variances were equal for participants with and without PTSD, $F_{1,163} = 0.72$, $p = 0.40$. Correcting for multiple comparisons, there was no significant difference in age between participants who had PTSD (mean = 49.53, SD = 10.76), and participants who did not (mean = 53.20, SD = 11.30), $t_{163} = 2.09$, Cohen's $d = 0.33$, $p = 0.038$, 95% CI, 0.21-7.13.

Sensitivity to pain traumatization and pain catastrophizing

An independent-samples t -test was conducted to evaluate whether SPT scores of CAF personnel with chronic pain differed between those who had PTSD and those who did not. The output of the Q-Q Plot revealed SPT scores were normally distributed. A Kolmogorov-Smirnov test confirmed SPT scores followed a normal distribution, $D_{164} = 0.05$, $p = 0.20$. A Levene's test confirmed variances were equal for participants with and without PTSD, $F_{1,162} = 0.01$, $p = 0.92$. SPT of participants with PTSD (mean = 26.65, SD = 9.37) was significantly higher than SPT of participants without PTSD (mean = 18.49, SD = 9.15), $t_{162} = 5.47$, Cohen's $d = 0.88$, $p < 0.001$, 95% CI, 11.11-5.22.

An additional independent-samples t -test was conducted to evaluate whether PCS scores in CAF members with chronic pain differed between those with PTSD and those without. Visual analysis of the Q-Q plot revealed PCS scores were normally distributed, and normality was confirmed by a Kolmogorov-Smirnov test, $D_{165} = 0.06$, $p = 0.10$. A Levene's test confirmed variances were equal for participants with and without PTSD, $F_{1,163} = 0.04$, $p = 0.83$. Pain catastrophizing of participants with PTSD (mean = 28.85, SD = 11.30) was significantly higher than participants without PTSD (mean = 18.70, SD = 11.07), $t_{163} = 5.67$, Cohen's $d = 0.91$, $p < 0.001$, 95% CI, 13.68-6.61.

For the mediation analysis, PDI residuals were assessed for assumptions of normality and homoscedasticity. The normal probability-probability (P-P) plot revealed residuals were normally distributed. The scatterplot of PDI residuals revealed residuals were equally distributed. Therefore, the assumption of homoscedasticity was met. The scatterplot displaying the association between SPTS and PDI scores also revealed the relationship between these variables is linear. The scatterplot displaying the association between PCS and PDI scores revealed a linear relationship between these variables. Multicollinearity diagnostics were assessed to

Table 2. Socio-demographic characteristics by PTSD status as a percentage of the sample

Characteristic	With PTSD n = 101		Without PTSD n = 64	
	Percentage	Number	Percentage	Number
Age (in years)				
18-29	2.0	2	0	0
30-39	15.8	16	14.1	9
40-49	26.7	27	25	16
50-59	39.6	40	26.6	17
60+	15.8	16	34.4	22
Gender				
Male or primarily masculine	73.3	74	82.8	53
Female or primarily feminine	24.8	25	15.6	10
Non-binary	2.0	2	1.6	1
Culture				
Asian	1.0	1	1.6	1
Latin/South American	1.0	1	3.1	2
Caribbean	2.0	2	0.0	0
White/Caucasian	82.0	82	79.7	51
Indigenous	4.0	4	1.6	1
Middle Eastern	1.0	1	0.0	0
Other	10.0	10	14.1	9
Country of current residence				
Canada	98.0	99	100.0	64
United States	1.0	1	0.0	0
Australia	1.0	1	0.0	0
Relationship status				
Single	11.9	12	4.7	3
In a relationship	61.4	62	84.4	54
Other	26.8	27	10.9	7
Education level completed				
Less than high school	3.0	3	1.6	1
High school or GED	13.9	14	17.2	11
Trade certificate or diploma	11.9	12	18.8	12
College or other non-university certificate or diploma	20.8	21	23.4	15
Some university completed	13.9	14	18.8	12
Bachelor's degree	19.8	20	6.3	4
Some graduate or professional school completed after bachelor's degree	4.0	4	3.1	2
University degree, diploma, or certificate above the bachelor's level	12.9	13	10.9	7
Income				
less than CAD\$25,000	1.0	1	1.6	1
CAD\$25,001-CAD\$50,000	11.9	12	10.9	7
CAD\$50,001-CAD\$75,000	32.7	33	40.6	26
CAD\$75,001-CAD\$100,000	27.7	28	23.4	15
CAD\$100,001 or greater	23.8	24	18.8	12
Did not disclose	3.0	3	4.7	3

PTSD = posttraumatic stress disorder; GED = General Educational Development.

determine whether SPT and pain catastrophizing variables were highly collinear. The VIF for SPT and pain catastrophizing was 3.02, indicating the two variables were moderately collinear. However, this value was not considered problematic given that the VIF value was less than 5, the value at which regression coefficients may be considered poorly estimated due to multicollinearity.²⁶ Condition indices were 1.00, 5.02, and 9.62. As each condition index was below 30, multicollinearity was not an issue.²⁷ Therefore, because SPTS and

PCS were not highly collinear, both could be included in the same mediation model to assess their simultaneous effects on the relationship between PTSD and pain-related disability.

Parallel mediation model

A parallel mediation analysis was conducted to examine whether SPT and pain catastrophizing mediated the relationship between PTSD presence and severity of pain-related disability among CAF personnel with

Table 3. Military status and characteristics as a percentage of the sample

Characteristic	CAF Veteran		Current CAF member	
	Percentage	Number	Percentage	Number
	n = 127		n = 38	
Component of the CAF				
Regular Force	67.3	111	19.4	32
Reserve Force	9.1	15	3.6	6
Did not disclose	0.6	1	0.0	0
Rank group				
Junior non-commissioned member	32.1	53	7.9	13
Senior non-commissioned member	27.3	45	5.5	9
Junior officer	10.3	17	6.1	10
Senior officer	6.7	11	3.6	6
Did not disclose	0.6	1	0.0	0
Military branch				
Royal Canadian Air Force	15.8	26	4.2	7
Canadian Army	33.9	56	15.8	26
Royal Canadian Navy	14.5	24	1.2	2
Purple Trade	12.7	21	1.8	3

CAF = Canadian Armed Forces.

Table 4. Pain condition as a percentage of the sample

Characteristic	Number	Percentage*
Chronic pain condition		
Arthritis	105	63.6
Back pain	138	83.6
Pelvic pain	35	21.2
Fibromyalgia	14	8.5
Endometriosis	4	2.4
Phantom limb pain	4	2.4
Inflammatory bowel disease (including Crohn's disease and/or ulcerative colitis)	3	1.8
Irritable bowel syndrome	28	17.0
Migraine headaches	53	32.1
Prefer not to answer	1	0.6
Don't know	1	0.6

* Percentages add up to greater than 100 as 75% of participants endorsed multiple chronic pain conditions.

chronic pain. This model is detailed in [Figure 1](#) and [Table 6](#). There was a significant total effect of PTSD presence on pain-related disability when the effect of the mediators was not included in the model (c pathway) ($\beta = 0.69$, $SE = 2.16$, $p < 0.001$). There was a significant effect of PTSD presence on both SPT (a_1 pathway) ($\beta = 0.79$, $SE = 1.50$, $p < 0.001$) and pain catastrophizing (a_2 pathway) ($\beta = 0.82$, $SE = 1.84$, $p < 0.001$). In turn, there was a significant effect of SPT on pain-related disability (b_1 pathway) ($\beta = 0.42$, $SE = 0.15$, $p < 0.001$), but no significant effect of pain catastrophizing on pain-related disability (b_2 pathway) ($\beta = 0.20$, $SE = 0.12$, $p = 0.06$).

Table 5. Pain characteristics of the sample

Characteristic	Mean (SD)	Sample range
Chronic pain duration (years)	16.92 (11.41)	2.17-60.75
Chronic pain intensity	5.57 (1.83)	0.00-10.00
Chronic pain interference	40.96 (16.68)	2.00-70.00
Pain Disability Index scores	38.77 (14.02)	3.00-63.00

The specific indirect effect of SPT on the relationship between PTSD presence and pain-related disability was significant (a_1b_1) ($\beta = 0.34$, $SE = 0.10$, 95% CI, 0.15-0.54). This means that with 95% confidence, PTSD presence influences pain-related disability indirectly through SPT. Individuals with PTSD were estimated to score 4.72 units higher on pain-related disability than individuals without PTSD because of the tendency of those with PTSD to have higher SPT, which, in turn, was positively related to pain-related disability. The specific indirect effect of pain catastrophizing on the relationship between PTSD presence and pain-related disability was significant (a_2b_2) ($\beta = 0.17$, $SE = 0.09$, 95% CI, 0.01-0.36). With 95% confidence, PTSD presence influences pain-related disability indirectly through pain catastrophizing. Individuals with PTSD were estimated to score 2.32 units higher on pain-related disability than individuals without PTSD because of the tendency of those with PTSD to have higher catastrophic thinking about pain, which, in turn, effected pain-related disability.

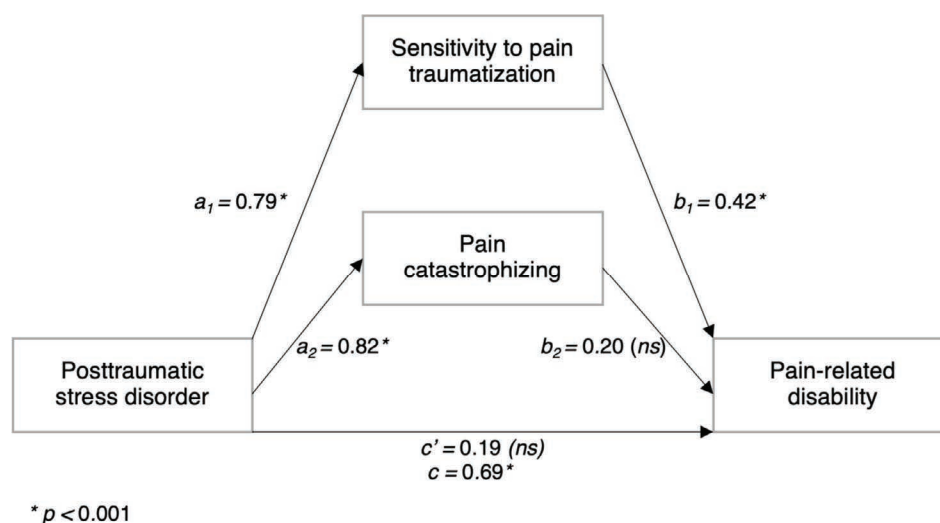


Figure 1. Mediation of the relationship between PTSD and pain-related disability by sensitivity to pain traumatization and pain catastrophizing

Pairwise comparisons of both specific indirect effects revealed SPT and pain catastrophizing were not statistically different from each other (95% CI, 2.22-6.71), meaning the effect of either mediator was not significantly larger than the other. After including the two mediators, the direct effect (c') of PTSD on pain-related disability was no longer significant ($\beta = 0.19$, $SE = 1.94$, $p = 0.17$). Approximately 11.5% of the variance in pain-related disability was accounted for by PTSD presence, and 41.5% of the variance in pain-related disability was accounted for by the combination of PTSD presence and the SPT and pain catastrophizing mediators. This parallel mediation analysis revealed that, while holding the other mediator constant, both

SPT and pain catastrophizing significantly mediated the relationship between PTSD and pain-related disability.

To verify the separate, significant mediation effect of each mediator on the relationship between SPT presence and pain-related disability, SPT and pain catastrophizing were inputted into two separate simple mediation models. Results reflected the parallel mediation model in that both SPT and pain catastrophizing significantly moderated the relationship between PTSD presence and pain-related disability in their respective models. The specific indirect effect of SPT was significant (ab) ($\beta = 0.46$, $SE = 0.10$, 95% CI, 0.28-0.66), and the specific indirect effect of pain catastrophizing was significant (ab) ($\beta = 0.44$, $SE = 0.09$, 95% CI, 0.27-0.62).

Table 6. Path coefficients, indirect effects, and 95% confidence intervals for sensitivity to pain traumatization and pain catastrophizing mediating the relationship between PTSD and pain-related disability

Path	Effect (standardized)	Effect (unstandardized)	95% CI		SE	t	p
			(Lower, upper)				
Total effect (c)	0.693	9.734	5.465-14.004		2.161	4.504	< 0.001
Direct effect (c')	0.192	2.695	-1.145-6.535		1.944	1.387	0.168
A paths							
a_1	0.792	7.876	4.918-10.834		1.498	5.259	< 0.001
a_2	0.819	10.052	6.420-13.684		1.839	5.466	< 0.001
B paths							
b_1	0.424	0.599	0.298-0.901		0.152	3.933	< 0.001
b_2	0.202	0.231	-0.015-0.476		0.124	1.858	0.065
Indirect effects							
Total	0.501	7.039	0.319-0.709		0.100		
a_1b_1	0.336	4.721	0.150-0.540		0.100		
a_2b_2	0.165	2.318	0.013-0.361		0.090		

PTSD = posttraumatic stress disorder.

DISCUSSION

This study examined the relationship between PTSD and pain-related disability in a sample of CAF members and Veterans with chronic pain. Participants with PTSD reported significantly higher pain-related disability than participants without PTSD, in line with the study's first hypothesis. The study then investigated the hypothesis that SPT and pain catastrophizing mediate the relationship between PTSD presence and pain-related disability. This parallel mediation analysis revealed that, while controlling for the other mediator, each psychological factor significantly mediated the relationship between PTSD and pain-related disability. Analyses demonstrated a significant specific indirect effect for SPT and a significant specific indirect effect for pain catastrophizing. These findings also provide evidence that both SPT and pain catastrophizing are distinct psychological processes. Taken together, findings suggest military personnel with comorbid PTSD and chronic pain may experience heightened pain-related disability because PTSD may increase an individuals' susceptibility to becoming traumatized by pain and a tendency to experience catastrophic thoughts about pain.

The finding that CAF members and Veterans with chronic pain who also had PTSD reported greater severity of pain-related disability compared to those who did not have PTSD is consistent with the authors' hypothesis and with previous research demonstrating comorbid PTSD and chronic pain was associated with significantly increased levels of affective distress compared to Veterans with chronic pain alone.⁶ Similarly, the finding that participants with PTSD reported significantly higher scores on both the SPTS and the PCS compared to those without PTSD aligns with previous literature. As previously discussed, a strong positive correlation was found between SPT and symptoms of PTSD.¹¹ Similarly, pain catastrophizing has also been found to significantly contribute to variance in PTSD severity.²⁸ Therefore, current findings replicate past research demonstrating the deleterious relationship between PTSD and SPT and PTSD and pain catastrophizing.

The parallel mediation analysis revealed PTSD increased pain-related disability both directly and indirectly through SPT and pain catastrophizing. This indicates the occurrence of PTSD was associated with increased symptoms of SPT and pain catastrophizing, and that, together, these mediators were associated with increased pain-related disability. While there was not a

significant effect of pain catastrophizing on pain-related disability, there was a significant effect of PTSD on pain catastrophizing, and a significant total indirect effect of pain catastrophizing on the relationship between PTSD and pain-related disability. This finding aligns with previous research, as past studies examined pain catastrophizing as mediators of similar relationships. For example, previous research found the tendency to experience catastrophic thoughts about pain mediated the relationship between PTSD symptoms and both pain severity and pain interference in adults with chronic pain.²⁹ However, the study also builds on previous research by demonstrating that pain catastrophizing not only mediates the relationship between PTSD and pain itself, but also PTSD and pain-related disability. In addition, this is the first study to demonstrate that SPT mediates the relationship between PTSD and pain-related disability. This means military personnel with PTSD may be more susceptible to developing a traumatic stress-like reaction to chronic pain, which may increase pain-related disability.

Implications

Findings of this study add to existing literature on comorbid PTSD and chronic pain by identifying two potential mechanisms underlying the relationship between PTSD and increased pain-related disability in military personnel with chronic pain. Results indicate both SPT and pain catastrophizing mediate the relationship between PTSD and pain-related disability. Findings suggest treatments for military personnel suffering from comorbid chronic pain and PTSD may benefit from treatment strategies targeting an individual's tendency to catastrophize about pain, such as cognitive behavioural therapy.

If an individual demonstrates a heightened sensitivity to pain traumatization, it may also be beneficial to identify and treat pain reactions resembling a traumatic stress symptom. For instance, a CAF member experiencing dissociative reactions when in pain can be provided with grounding or mindfulness strategies to reduce dissociative avoidance of pain symptoms. Evidence from a four-week interdisciplinary chronic pain management program (the Michael G. DeGroot Pain Clinic — Intensive Chronic Pain Management Program) suggests psychotherapy and mindfulness contribute to significant reductions in pain catastrophizing, SPT, and pain-related disability for individuals with chronic pain.³⁰ There were significant improvements between

admission and discharge in all three of these measured variables for Veterans enrolled in the program.³⁰

Furthermore, the significant effect of SPT on pain-related disability suggests targeting SPT reduction in individuals with chronic pain, even if they do not have comorbid PTSD, could help reduce pain-related disability. Because SPT symptoms resemble the features of a traumatic stress reaction,^{11,12} treatments for SPT approximating interventions for PTSD might be highly effective at reducing SPT and, in turn, pain-related disability. Prolonged exposure therapy is one example of an intervention that could be adapted for SPT reduction. For instance, *in vivo* exposure therapy, which was shown to reduce pain-related disability for a variety of chronic pain disorders,³¹ might benefit from the addition of imaginal exposure practice (wherein the client recounts a particularly vivid pain episode, repeatedly, and in detail) and subsequent processing of the thoughts and emotions arising during exposure practice with a therapist. Treatment strategies such as those above may mitigate pain-related disability and improve quality of life.

Limitations and future directions

Results of this study should be considered in the context of its statistical limitations. The study was cross-sectional; therefore, it is unknown if participants' development of PTSD preceded any vulnerability to developing a traumatic stress-like response to pain or any tendency to engage in catastrophic thinking about pain. Future longitudinal studies are necessary to determine whether developing PTSD leads to a heightened vulnerability to pain traumatization and increased catastrophic thinking about pain, and whether these psychological constructs lead to increased pain-related disability. A repeated measures analysis would allow for examination of temporal precedence and provide elementary support for a causal relationship between PTSD, SPT and pain catastrophizing, and pain-related disability. There is already some evidence suggesting anxiety sensitivity, a psychological factor related to SPT,¹¹ contributes prospectively to the development of PTSD.³² It will be important for future studies to determine whether SPT also contributes to PTSD, whether the directionality of this relationship is reversed, or whether SPT and PTSD act to mutually maintain and exacerbate each other.

Conclusion

Results of this study demonstrated a significant association between PTSD and pain-related disability, such

that military personnel with comorbid PTSD and chronic pain experienced greater pain-related disability than military personnel with chronic pain only. SPT and pain catastrophizing significantly mediated the relationship between PTSD presence and severity of pain-related disability, suggesting SPT and catastrophic thinking about pain may be underlying cognitive mechanisms through which PTSD symptoms increase the severity of pain-related disability. Results of this study add to knowledge of the relationship between PTSD and chronic pain and may contribute to the development of more effective treatment strategies for military personnel experiencing pain-related disability due to chronic pain.

AUTHOR INFORMATION

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COMPETING INTERESTS

The authors have nothing to disclose.

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ETHICS APPROVAL

This study was approved by the Queen's University Health Sciences and Affiliated Teaching Hospitals Research Ethics Board, Kingston, Ontario, Canada on Jul. 17, 2019.

INFORMED CONSENT

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