ORIGINAL ARTICLE

Sensitivity to pain traumatization: A higher-order factor underlying pain-related anxiety, pain catastrophizing and anxiety sensitivity among patients scheduled for major surgery

Valery Kleiman MA[1], Hance Clarke MSc MD[2,3], Joel Katz PhD[1,2,3]

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BACKGROUND: The present article addresses two related developments in the psychology of pain, and integrates them into a coherent framework to better understand the relationship between pain and trauma. The first is an emerging conceptualization regarding the nature of the hierarchical organization of major pain-related anxiety constructs. The second is the theoretical rationale and empirical evidence linking pain and symptoms of post-traumatic stress disorder.
OBJECTIVES: To explore the underlying hierarchical factor structure of commonly used pain-related anxiety measures including the Pain Anxiety Symptoms Scale (PASS-20), the Pain Catastrophizing Scale (PCS), and the Anxiety Sensitivity Index (ASI); and to relate this structure to post-traumatic stress disorder in patients scheduled for major surgery.
METHODS: Measures were completed by 444 patients scheduled to undergo major surgery. Exploratory factor analysis and subsequent higher-order analysis using the Schmid-Leiman transformation were conducted to investigate the underlying factor structure of the ASI, the PCS and the PASS-20.
RESULTS: Twenty items from the ASI, the PASS-20 and the PCS loaded exclusively on one higher-order factor. The authors suggest the term 'sensitivity to pain traumatization' (SPT) for the underlying construct based in part on the strong, significant positive correlation between SPT scores and scores on the Post-traumatic Stress Disorder Checklist – Civilian Version. Finally, the total SPT score was significantly higher for patients with a history of pain than for those without a history of pain, both before surgery and one year after surgery. SPT describes the propensity to develop anxiety-related somatic, cognitive, emotional and behavioural responses to pain that resemble features of a traumatic stress reaction. Together, the results of the present study provide preliminary evidence for the construct validity of SPT.

Key Words: *Anxiety sensitivity; Factor analysis; Pain anxiety; Pain catastrophizing; Post-traumatic stress disorder; Surgery*

La sensibilité au traumatisme de la douleur : Un facteur d'ordre supérieur sous-jacent à l'anxiété liée à la douleur, à la catastrophisation de la douleur et à la sensibilité à l'anxiété chez des patients devant subir une opération majeure

HISTORIQUE : Le présent article porte sur deux évolutions connexes de la psychologie de la douleur et les intègre à un cadre cohérent pour mieux comprendre le lien entre la douleur et les traumatismes. Le premier est une conceptualisation émergente au sujet de la nature de l'organisation hiérarchique des concepts d'anxiétés liés à de fortes douleurs. Le deuxième est le fondement théorique et les données empiriques liant la douleur aux symptômes du syndrome de stress post-traumatique.
OBJECTIFS : Explorer la structure des facteurs hiérarchiques sous-jacents des mesures d'anxiété liées à la douleur couramment utilisées, y compris l'échelle des symptômes d'anxiété liée à la douleur (PASS-20), l'échelle de catastrophisation de la douleur (PCS) et de l'indice de sensibilité de l'anxiété (ASI); et lier cette structure au syndrome du stress post-traumatique chez les patients devant subir une opération majeure.
MÉTHODOLOGIE : Les mesures ont été remplies par 444 patients qui devaient subir une chirurgie majeure. Les chercheurs ont procédé à l'analyse des facteurs exploratoires et à l'analyse de l'ordre supérieur subséquent au moyen de la transformation de Schmid-Leiman pour évaluer la structure de facteurs sous-jacents de l'ASI, de la PCS et de la PASS-20.
RÉSULTATS : Vingt éléments de l'ASI, de la PASS-20 et de la PCS portaient exclusivement sur le facteur d'ordre supérieur. Les auteurs suggèrent le terme « sensibilité au traumatisme de la douleur » (STD) pour désigner le concept sous-jacent fondé en partie sur la corrélation positive solide et significative entre les indices de STD et les indices de la version civile de la liste de troubles liés au syndrome de stress post-traumatique. Enfin, l'indice de STD total était considérablement plus élevé chez les patients ayant des antécédents de douleur que chez ceux sans antécédents de douleur, tant avant l'opération qu'un an après l'opération. La STD décrit la propension à développer des réactions somatiques, cognitives, affectives et comportementales liées à la douleur, qui ressemblent aux caractéristiques d'une réaction de stress traumatique. Ensemble, les résultats de la présente étude procurent des données probantes préliminaires pour valider le concept de STD.

There is an extensive body of research aimed at identifying key psychological constructs related to the experience of pain. A range of cognitive, affective and behavioural factors have been found to influence the perception of pain, maintenance of pain and disability, exacerbation of pain and response to treatment (1-6). Recent advances in research pertaining to anxiety-related correlates of pain suggest consideration of comprehensive models that include several inter-related constructs. Diathesis-stress (6) and fear/anxiety-avoidance (7,8) models of chronic pain are examples of recent frameworks that have received considerable empirical support. Both models propose several anxiety-related constructs, including pain anxiety (9), pain catastrophizing (10,11) and anxiety sensitivity (12), which separately, have been shown to be correlated with the experience of pain.

Concurrent with the above developments, there is a growing body of empirical and theoretical literature pertaining to the interconnection between pain and symptoms of post-traumatic stress disorder (PTSD) (for review, see reference 13). Current conceptualizations indicate that chronic pain, PTSD and PTSD symptoms (PTSS) are inter-related through shared vulnerability and mutual maintenance mechanisms (13,14). In addition, an examination of the item content of the most frequently used pain-related anxiety measures (eg, the Pain Anxiety Symptoms Scale-20, short form

[1]*Department of Psychology, Faculty of Health, York University;* [2]*Department of Anesthesia and Pain Management, Toronto General Hospital and Mount Sinai Hospital;* [3]*Department of Anesthesia, University of Toronto, Toronto, Ontario*
Correspondence: Dr Joel Katz, Department of Psychology, Behavioral Sciences Building, York University, 4700 Keele Street, Toronto, Ontario M3J 1P3. Telephone 416-736-2100 ext 40557, e-mail jkatz@yorku.ca

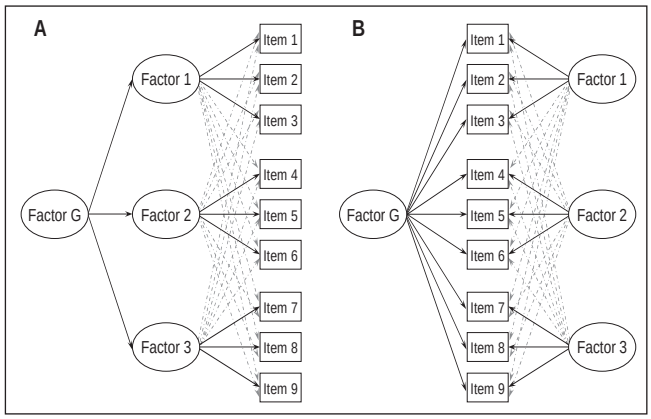

Figure 1) *Higher-order factor analysis models showing a typical two-level higher-order model (**A**) and a bifactor hierarchical model based on the Schmid-Leiman (50) transformation (**B**) used in the present study. Both models are comprised of nine primary variables (scale items 1 to 9), three first-order factors and a general factor (Factor G); however, the bifactor hierarchical model permits calculation of a direct relationship between the general factor and each scale item, and ensures that the variance in scale items explained by Factor G and domain-specific factors is orthogonal, thereby facilitating interpretation of the relative contribution of the former and latter factors to the explanation of scale items. Adapted from references 32 and 35*

[PASS-20 (15)], the Pain Catastrophizing Scale [PCS (10)] and the Anxiety Sensitivity Index [ASI (12)]) indicates that many items can be grouped into three main clusters associated with traumatic stress reactions (re-experiencing of pain, avoidance of pain and pain-related hyperarousal), suggesting a general pain-related traumatic stress factor. However, to our knowledge, there has not been any empirical research on how pain anxiety, pain catastrophizing, anxiety sensitivity and PTSS relate to one another.

Important advances have been made in establishing the reliability and validity of the instruments measuring pain anxiety, pain catastrophizing and anxiety sensitivity (8,16-21); however, research pertaining to the conceptual relationships among these constructs has lagged behind the psychometric studies (22,23). There is preliminary evidence for the construct independence of pain anxiety and anxiety sensitivity (24,25), and the suggestion that anxiety sensitivity, pain anxiety and pain catastrophizing correlate with different outcome variables (26). However, numerous studies also suggest close interrelationships, and even overlap, among these pain-related anxiety constructs (22,27,28). Item overlap among scales is evident, suggesting similarities in their 'broader meaning' (23). Furthermore, converging theoretical conceptualizations propose that the various anxiety-related constructs are hierarchically related (22,29). Hierarchical conceptualizations suggest that there is a heretofore unidentified, general, higher-order factor underlying the domain-specific, lower-level, pain-related anxiety constructs such as anxiety sensitivity, pain anxiety and pain catastrophizing (22).

Although there is general agreement that the various pain-related anxiety constructs should be considered as part of an inter-related hierarchy, the specific relationships and hierarchical connections among these constructs remain largely understudied. For example, some argue that pain anxiety is a manifestation of anxiety sensitivity (30,31), whereas others suggest that pain anxiety is a fundamental fear on its own (25). To our knowledge, only one study has evaluated the hierarchical organization of various pain-related anxiety constructs. Vancleef et al (23) had undergraduate students engage in a card-sorting task of items from nine pain-related anxiety scales including measures of anxiety sensitivity, pain anxiety and pain catastrophizing. Using cluster analysis and multidimensional scaling techniques, the authors proposed a hierarchy involving four main clusters: negative emotions and anxiety; cognitive performance concerns; physical health concerns; and pain-specific concerns.

Another approach to studying the hierarchical structure underlying a set of variables involves higher-order factor analysis. Hierarchical models have a long history in the areas of intelligence research, personality, self-concept and psychological well-being (32); however, their application to the field of pain has been limited (eg, reference 33). Hierarchical representations propose that there are several related domains that comprise one general underlying construct (34,35) as shown in models A and B in Figure 1. Model A depicts a second-order model involving a higher-order factor (Factor G) that accounts for the relationships among the three first-order factors that are composed of nine primary variables; in the present example, nine individual scale items. Model B depicts an alternative, bifactor hierarchical model. In this model, the variance in scale items attributable to the general underlying factor (Factor G) has been maximized, Factor G maps directly onto each of the nine scale items, and the three domain-specific factors capture item-specific construct covariation that is independent of the covariation due to the general factor. At the item level, the bifactor hierarchical model proposes a general factor (Factor G) that accounts for the communality of the individual items and multiple domain-specific factors – each of which accounts for the unique influence of the specific domain over and above the general factor. Bifactor hierarchical and second-order models are not generally equivalent mathematically (35). Moreover, there is a key conceptual difference between a second-order factor and a general factor in bifactor models (36). A second-order factor is usually considered to comprise a qualitatively different type of dimension – a superordinate dimension. In a bifactor model, the general factor is on the same conceptual level as the group factors because it represents another possible source of item variance. The mathematical and conceptual advantages of the bifactor hierarchical representation (Figure 1, model B) over the traditional higher-order model (Model A) (34,36,37) are especially evident when there are several highly correlated measures with possible item and content overlap – a situation that exists for pain anxiety, pain catastrophizing and anxiety sensitivity (23).

To summarize, there is compelling evidence of the pivotal role of pain-related anxiety constructs in pain experience; the most commonly used pain-related anxiety constructs (namely, pain anxiety, pain catastrophizing and anxiety sensitivity) seem to be closely inter-related and even overlapping; there is an emerging trend to consider hierarchical organizations of pain-related anxiety constructs; and there is a conceptualization that chronic pain and PTSS are connected by specific anxiety constructs, representing shared vulnerability and suggesting a general pain-related traumatic stress factor. Thus, the aim of the present study was to investigate the hierarchical relationship underlying pain anxiety, pain catastrophizing and anxiety sensitivity in a clinical sample of patients undergoing major surgery, as well as to conduct a preliminary analysis of the relationship between the hypothesized underlying hierarchical factor and PTSS.

METHODS

Patients were recruited as part of a larger study examining biopsychological factors associated with acute and long-term postoperative pain. The study was reviewed and approved by the Research Ethics Boards of the Toronto General Hospital and York University in Toronto, Ontario.

Participants

The present study used the same sample reported by Page et al (38). The sample comprised 484 patients scheduled to undergo major surgery at the Toronto General Hospital. Patients were recruited between January 2003 and August 2006. Two participants did not complete any of the questionnaires. Due to an excessive amount of missing data (50% or more), an additional two patients were excluded from further analysis. Another 29 cases were identified as multivariate outliers and were excluded from the analysis. The final sample used in the

analysis consisted of 444 patients (men: n=174, age 18 to 60 years [mean ± SD 45.4±11.3 years]; women: n=270, age 18 to 60 years [mean 46.0±9.5 years]). The participants only partially reported racial demographics. Of the final total sample of 444 participants, 36.3% did not report their race/ethnicity, 25.2% defined their race/ethnicity as Canadian, 7.5% defined themselves as Asian and 2.4% as African-Canadian. With regard to education, 5.2% had completed less than grade 12, 30.9% had completed grade 12, 39% had an undergraduate college or university degree, and 24.3% had a graduate university degree. At the time of initial contact, 75.9% had full- or part-time employment.

Inclusion criteria

Patients who were undergoing major surgery and were to receive intravenous or epidural opioids via a patient-controlled analgesia pump postoperatively for at least 48 h; patients who were 18 to 60 years of age; and patients who were proficient in reading and writing English.

Exclusion criteria

Patients scheduled for other regional anesthetic techniques during or after surgery.

Procedure

Prospective patients were identified and recruited at their preadmission appointment, on average, 11±14.2 days before surgery. Following informed written consent, patients completed the presurgery set of questionnaires, and were followed up by telephone at six and 12 months after surgery to assess the nature and extent of persistent postsurgical pain. Patients were telephoned a maximum of three times. A voice message was left on the third call. Patients were considered to be lost to follow-up if they could not be reached and did not return the call.

Measures

Current pain and pain history questionnaire: This questionnaire includes questions pertaining to the patient's current pain condition, analgesic use, interference with life, previous pain experiences and expectations regarding pain they may experience after surgery (see reference 38 for more information).

PASS-20: The PASS-20 (15) is a 20-item short form of the larger 40-item PASS (9) that measures fear and anxiety responses to pain. Analysis of the original PASS revealed four subscales labelled "Cognitive", "Escape and Avoidance", "Fear", and "Physiological Anxiety". McCracken and Dhingra (15) reported that these subscales retained good psychometric properties in the shortened version of the scale. PASS-20 is a reliable and valid scale with adequate psychometric properties. Cronbach's alpha values for PASS-20 total score were reported in the range of 0.91 to 0.92 (18). Cronbach's alpha for the PASS-20 in the present study was 0.95.

PCS: The term 'pain catastrophizing' is used to describe a particular response to pain symptoms that includes elements of rumination (ie, excessive focus on pain sensations), magnification (ie, exaggerating the threat value of pain sensations) and helplessness (ie, perceiving oneself as unable to cope with pain symptoms). The PCS consists of 13 items describing different thoughts and feelings that individuals may experience when they are in pain (10). The PCS instructions ask participants to reflect on past painful experiences, and to indicate the degree to which they experienced each of 13 thoughts or feelings when experiencing pain, on five-point scales with end points of 0 (not at all) and 4 (all the time). The PCS yields a total score and three subscale scores assessing rumination, magnification and helplessness. The PCS has been shown to have adequate to excellent internal consistency (10). Cronbach's alpha for the PCS in the present study was 0.94.

ASI: Anxiety sensitivity refers to a fear of anxiety-related sensations based on the belief that these sensations have harmful consequences (39). The ASI is a widely used 16-item scale that measures anxiety sensitivity as a dispositional construct (12). Each item expresses a concern regarding possible negative consequences of anxiety symptoms and is rated on a five-point Likert scale ranging from 0 (very little) to 4 (very much). Blais et al (40) reported that the scale includes four components. The first is fear of somatic sensations of anxiety, the second is fear of losing emotional control or looking nervous to others, the third is fear of losing mental control, and the last factor is concern regarding gastrointestinal sensations. Blais et al (40) also reported that their analysis of the psychometric properties of the ASI revealed five weak items, and they suggested using a refined 11-item version of the scale. For the present study, the longer 16-item ASI questionnaire was used. Overall, the scale has produced an acceptable alpha coefficient in the range of 0.80 to 0.90 (41). Cronbach's alpha for the ASI in the present study was 0.87.

PTSD Checklist – Civilian Version: The PTSD Checklist – Civilian Version (PCL-C) is a 17-item self-report measure (42). Each item is a statement based on the current *Diagnostic and Statistical Manual of Mental Disorders* (DSM)-IV symptoms for PTSD. Respondents are asked to indicate how much they have been bothered by each symptom over the previous month on a scale from 1 (not at all) to 5 (extremely). The questionnaire produces a total score as well as subscale scores for re-experiencing, avoidance/numbing and hyperarousal. The PCL-C has been shown to have excellent internal consistency in Vietnam and Persian Gulf veterans, victims of motor vehicle accidents and sexual assault survivors (r ranging from 0.94 to 0.97) (42,43). Test-retest reliability for the PCL-C over a two- to three-day retest interval is 0.96 (42). The PCL-C yields an adequately high overall diagnostic efficiency, and is both reliable and valid (42,43). Cronbach's alpha for the PCL-C in the present study was 0.92.

Data analysis

Analyses followed current recommendations for exploratory factor analysis (EFA) of ordinal data (44,45). EFA was conducted on the matrix of polychoric correlations using principal axis factoring with subsequent Promax rotation. Initial factor structures were assessed using parallel analysis (46), Velicer's MAP test (47,48) using O'Connor's syntax (44), eigenvalues of greater than 1, and Cattell's scree test. Item retention was based on factor loadings of 0.40 or greater. At least one-half of the items in each of the final factors were required to have loadings of 0.60 or greater to support factor stability (49).

The underlying factor structure was analyzed using a bifactor hierarchical model. Higher-order factor analysis was conducted using the Schmid-Leiman transformation (SLT [50]). Detailed descriptions of this hierarchical factor method, as well as SPSS (IBM Corporation, USA) and SAS (SAS Institute Inc, USA) syntax codes for SLT, are provided elsewhere (32).

RESULTS

Descriptive data

Initial assessment: For the purpose of subsequent analyses, the sample was divided into two groups based on the information provided in the current pain and pain history questionnaire administered at the presurgery hospital visit. Of the 444 patients, 261 (59%) reported no ongoing pain problems and were not currently experiencing pain. These patients constituted the no pain group (Group NP – men: n=105, age 18 to 59 years [mean 44.6±11.6 years]; women: n=156, age 18 to 60 years [mean 45.7±9.9 years]). One hundred sixty patients (36%) reported ongoing pain problems, with 53.46% of these patients also reporting pain at the time of the interview. These patients comprised the pain group (Group P – men: n=65, age 22 to 60 years [mean 47±10.6 years]; women: n=95, age 21 to 60 years [mean 45.8±9.2 years]). Details of the pain experienced by patients in Group P before surgery are summarized in Table 1. Fifteen patients (3.4%) reported no ongoing pain problems, while experiencing pain at the time of the assessment. These patients were included in the analysis of the full sample, but were excluded from the analysis according to group (Group P versus Group NP). Another eight patients (1.8%) did not respond to the items that dealt with ongoing and current pain. They were also included in the analysis of the full sample, but excluded from

TABLE 1
Pain Information from the Current Pain & Pain History Questionnaire for Pain Patients (n=160)

Do you have any ongoing pain problems?	Yes (n=160); no (n=0)
If yes, how long have you had pain for (in months)?	10.77±25.67
On the days that you feel pain, what is the average intensity of your pain on a scale from 1 to 10?	5.64±2.44
Currently feeling pain?	Yes (n=85); no (n=74)
If yes, what is the intensity of your pain on the scale from 1 to 10?	3.91±2.07
If yes, does pain interfere with your life (scale of 1 to 4)?	2.73±0.98
Are you currently taking pain medication?	Yes (n=82); no (n=75)
If yes, what type of pain medication?, n*	
Acetaminophen	2
Tylenol (Johnson & Johnson Inc, Canada)	24
Nonsteroidal anti-inflammatory drugs	7
Opioids	18
Others	46

*Data presented as mean ± SD unless otherwise indicated. *The total number exceeds the number of patients who reported taking pain medication because some patients reported taking more than one type of drug*

TABLE 2
Patient distribution by surgery type (n=444)

	Group	
Type of surgery	**Pain**	**No pain**
Abdominal gynecological	33 (20.6)	50 (19.2)
Lower abdominal	38 (23.8)	57 (21.8)
Upper abdominal	38 (23.8)	84 (32.2)
Thoracic	29 (18.1)	44 (16.9)
Laparoscopic	2 (1.3)	3 (1.1)
Other	20 (12.4)	23 (8.8)
Total	160 (100)	261 (100)

Data presented as n (%)

the analysis according to group. The two groups were not significantly different with regard to age (t[418]=1.02, P=0.32), sex (χ^2[1]=0.01, P=0.94) or history of previous surgeries (χ^2[1]=0.74, P=0.39). The distribution of surgery type within the two groups is presented in Table 2. There were no significant differences according to type of surgery between Groups P and NP (χ^2[5]=3.74, P=0.59). Descriptive statistics for the final sample are shown in Table 3.

The correlation matrix for the variables is shown in Table 4. There were no significant correlations between age and total scores of the measures, except for the ASI (r[444]=0.12, P=0.05). This correlation was sufficiently small to be considered of little consequence (51). The ANOVA comparing women and men revealed statistically significant differences on one measure: PASS-20 (F[1,442]=15.73, P=0.00). There was also a marginally significant sex difference on the ASI total score (F[1,442]=3.89, P=0.049]. These findings suggest that women had slightly higher pain anxiety scores than men; however, the effect sizes were small to moderate (52) (0.39 and 0.19, respectively). Consequently, neither sex nor age were considered separately to be factors in further analyses.

Nearly 12% (n=53) of the total sample scored at or above the cut-off score of 44 on the PCL-C (42,43) that corresponds to a DSM-IV-TR, diagnosis of PTSD. In Group P, 17.5% of the patients scored above the cut-off score, while only 8% of the Group NP patients scored 44 or greater on the PCL-C. However, there were no significant differences between Groups P and NP in the number of patients scoring 44 or greater on the PCL-C (χ^2[44]=36.49, P=0.78).

One-year follow-up: At the one-year follow-up, 328 patients completed the questionnaires. Of these, 48 (men: n=26 men, age 22 to 60 years [mean 43.50±12.08 years]; women: n=22, age 31 to 60 years [mean 46.05±7.76 years]) comprised a persistent pain group (Group PP) because they reported ongoing pain problems, some interference of pain with their lives and no additional surgeries since the initial surgery for which they had been recruited for the present study. Patients who reported no ongoing pain problems at the one-year follow-up as well as no pain at the time of the follow-up assessment comprised the no persistent pain group (Group NPP). Group NPP consisted of 242 patients (men: n=85, age 18 to 59 years [mean 45.86±11.78 years]; women: n=157, age 18 to 60 years [mean 46.09±9.59 years]).

TABLE 3
Descriptive statistics (n=444)

Variable	Mean ± SD	Range
Age, years	45.78±10.22	18–60
Anxiety sensitivity (ASI)	18.49±9.46	0–64
Pain catastrophizing (PCS)	16.49±10.49	0–52
Pain anxiety (PASS-20)	35.51±20.13	0–96
PTSD symptoms (PCL-C)	30.66±11.01	17–83

ASI Anxiety Sensitivity Index; PASS-20 Pain Anxiety Symptoms Scale, short form; PCL-C Post-traumatic Stress Disorder (PTSD) Checklist – Civilian Version; PCS Pain Catastrophizing Scale

TABLE 4
Correlation matrix (n=444)

	ASI	PCS	PASS-20	PCL-C	Age
Anxiety sensitivity (ASI)	1.00				
Pain catastrophizing (PCS)	0.61**	1.00			
Pain anxiety (PASS-20)	0.60**	0.71**	1.00		
PTSD symptoms (PCL-C)	0.41**	0.46**	0.44**	1.00	
Age	0.12*	0.08	0.08	–0.02	1.00

**P<0.05 level; **P<0.01 level. ASI Anxiety Sensitivity Index; PASS-20 Pain Anxiety Symptoms Scale, short form; PCL-C Post-traumatic Stress Disorder (PTSD) Checklist – Civilian Version; PCS Pain Catastrophizing Scale*

Initial EFA

At the first step, EFA was performed on the sample of 444 participants using all 49 items from the three anxiety-related measures: PASS-20, PCS and ASI. The initial run of EFA yielded several possible solutions for factor retention. Because factor retention decisions may be more critical than other relevant decisions in EFA (eg, choice of factor analytical method, type of rotation) (53), specific options suggested by the different factor retention methods are discussed below. Both the original (47) and revised minimum average partial (MAP [54]) tests on the matrix of polychoric correlations suggested extraction of one component. Parallel analysis suggested extraction of four factors, while the scree test suggested a three-factor solution. Using the eigenvalues of greater than 1 rule, a four-factor solution was suggested. Table 5 shows the factor matrix (unrotated) for the four-factor model. Although a simple structure cannot be obtained for eight items, there is already a strong suggestion of a single underlying factor, because all items, except items 1 and 5, from the ASI had high loadings (greater than 0.45) on the first factor. Of note, items 1 and 5 from the ASI did not load significantly on any factor in any other model. Table 6 provides a comparison of item loadings for the one-, four- and three-factor models. Rotated solution (Promax rotation) did not improve the four-factor model significantly because four items still had high cross-loadings. Similarly, when extraction of factors was limited to three, all items except ASI items 1 and 5 had high loadings on one factor in the initial unrotated factor matrix. Promax rotation of the three-factor model revealed a significant improvement over the four-factor rotated model because there were no significant cross-loadings between items. However, item 7 of the PCS did not have a sufficiently high loading on any of the factors. Interestingly, in all models, 47 of the 49 original items invariably loaded significantly on one large factor in the unrotated factor matrix and accounted for approximately 37% of the variance. Overall, the

TABLE 5
Unrotated factor matrix for four-factor solution (full sample)

Item	Factor I	Factor II	Factor III	Factor IV
ASI1 – It is important to me not to appear nervous	0.13	0.07	0.05	0.03
ASI2 – When I cannot keep my mind on a task, I worry that I might be going crazy	0.62	0.30	0.30	–0.12
ASI3 – It scares me when I feel “shaky” (trembling)	0.52	0.32	0.06	0.21
ASI4 – It scares me when I feel faint	0.45	0.30	0.08	0.37
ASI5 – It is important to me to stay in control of my emotions	0.16	0.11	0.03	0.15
ASI6 – It scares me when my heart beats rapidly	0.55	0.41	0.11	0.29
ASI7 – It embarrasses me when my stomach growls	0.47	0.22	0.17	0.03
ASI8 – It scares me when I am nauseous	0.53	0.30	0.16	0.08
ASI9 – When I notice that my heart is beating rapidly, I worry that I might have a heart attack	0.56	0.42	0.09	0.15
ASI10 – It scares me when I become short of breath	0.59	0.38	0.05	0.25
ASI11 – When my stomach is upset, I worry that I might be seriously ill	0.61	0.34	0.16	–0.06
ASI12 – It scares me when I am unable to keep my mind on a task	0.60	0.34	0.21	–0.01
ASI13 – Other people notice when I feel shaky	0.48	0.27	0.07	0.05
ASI14 – Unusual body sensations scare me	0.57	0.38	0.09	0.17
ASI15 – When I am nervous, I worry that I might be mentally ill	0.60	0.29	0.22	–0.19
ASI16 – It scares me when I am nervous	0.65	0.32	0.13	–0.10
PCS1 – I worry all the time about whether the pain will end	0.69	0.07	–0.28	–0.02
PCS2 – I feel I can’t go on	0.70	0.12	–0.15	–0.23
PCS3 – It’s terrible and I think it’s never going to get any better	0.71	0.18	–0.34	–0.23
PCS4 – It’s awful and I feel that it overwhelms me	0.72	0.11	–0.38	–0.13
PCS5 – I feel I can’t stand it anymore	0.72	0.09	–0.42	–0.15
PCS6 – I become afraid that the pain will get worse	0.70	0.07	–0.31	–0.09
PCS7 – I keep thinking of other painful events	0.59	0.08	–0.07	–0.21
PCS8 – I anxiously want the pain to go away	0.69	–0.06	–0.33	–0.03
PCS9 – I can’t seem to keep it out of my mind	0.73	0.03	–0.46	–0.02
PCS10 – I keep thinking about how much it hurts	0.74	–0.04	–0.44	0.02
PCS11 – I keep thinking about how badly I want the pain to stop	0.72	–0.12	–0.43	–0.04
PCS12 – There’s nothing I can do to reduce the intensity of the pain	0.62	0.04	–0.36	–0.16
PCS13 – I wonder whether something serious may happen	0.73	0.11	–0.12	–0.15
PASS1 – I can’t think straight when in pain	0.65	–0.21	–0.05	0.30
PASS2 – During painful episodes it is difficult for me to think of anything besides the pain	0.69	–0.24	–0.11	0.40
PASS3 – When I hurt I think about the pain constantly	0.74	–0.31	–0.11	0.36
PASS4 – I find it hard to concentrate when I hurt	0.70	–0.25	–0.14	0.41
PASS5 – I worry when I am in pain	0.77	–0.13	0.11	0.21
PASS6 – I go immediately to bed when I feel severe pain	0.55	–0.25	0.21	0.14
PASS7 – I will stop any activity as soon as I sense pain coming on	0.60	–0.36	0.15	0.11
PASS8 – As soon as pain comes on I take medication to reduce it	0.51	–0.30	0.06	0.11
PASS9 – I avoid important activities when I hurt	0.69	–0.36	0.17	0.09
PASS10 – I try to avoid activities that cause pain	0.54	–0.28	0.14	0.14
PASS11 – I think that if my pain gets too severe, it will never decrease	0.79	–0.12	0.14	–0.10
PASS12 – When I feel pain I am afraid that something terrible will happen	0.84	–0.11	0.18	–0.09
PASS13 – When I feel pain I think that I might be seriously ill	0.78	–0.09	0.24	–0.04
PASS14 – Pain sensations are terrifying	0.77	–0.22	0.21	–0.03
PASS15 – When pain comes on strong I think that I might become paralyzed	0.80	–0.06	0.22	–0.23
PASS16 – I begin trembling when engaged in an activity that increases pain	0.78	–0.15	0.25	–0.27
PASS17 – Pain seems to cause my heart to pound or race	0.75	–0.20	0.20	–0.23
PASS18 – When I sense pain I feel dizzy or faint	0.73	–0.23	0.27	–0.25
PASS19 – Pain makes me nauseous	0.60	–0.30	0.17	–0.17
PASS20 – I find it difficult to calm my body down after periods of pain	0.76	–0.28	0.16	–0.17

Items: ASI Anxiety Sensitivity Index; PASS Pain Anxiety Symptoms Scale, short form; PCS Pain Catastrophizing Scale

initial EFA strongly suggests that there are three separate factors, largely confirming previous findings on the uniqueness of the PASS-20, the PCS and the ASI. At the same time, there is a strong suggestion of a single underlying common factor.

Higher-order analysis

Because the three-factor solution appeared to be the preferable model in the first-order factor analysis, it was subjected to the higher-order analysis. The SLT yielded the pattern described in Table 7. Because there was only one second-order factor suggested, the results are equivalent to a bifactor solution depicted in Figure 1 (model B). The higher-order factor (Factor G) accounted for 68.3% of the common variance. According to Gorsuch (55), this higher-order factor represents an appropriate generalization of the relationship among items. Consistent with the first-order factor analysis, the SLT factor loadings in Table 7 reveal that items 1 and 5 of the ASI did not load on any

TABLE 6
Pattern matrix for one-, four- and three-factor solution (Promax rotation, n=444)

	1 factor	4 factors				3 factors		
Item	I	I	II	III	IV	I	II	III
ASI1	0.13	0.02	–0.02	0.15	0.02	0.02	0.15	–0.02
ASI2	0.62	0.40	–0.08	0.56	–0.19	0.17	0.75	–0.19
ASI3	0.52	–0.12	0.03	0.65	0.14	–0.07	0.58	0.11
ASI4	0.44	–0.25	–0.11	0.72	0.30	–0.06	0.53	0.06
ASI5	0.16	–0.11	–0.06	0.28	0.12	–0.03	0.21	0.01
ASI6	0.54	–0.20	–0.05	0.83	0.18	–0.12	0.72	0.06
ASI7	0.47	0.17	–0.05	0.46	–0.00	0.10	0.52	–0.07
ASI8	0.52	0.08	–0.04	0.59	0.02	0.02	0.63	–0.03
ASI9	0.55	–0.11	0.04	0.74	0.03	–0.15	0.74	0.08
ASI10	0.59	–0.18	0.05	0.76	0.16	–0.11	0.68	0.15
ASI11	0.61	0.19	0.08	0.57	–0.13	0.01	0.71	0.00
ASI12	0.59	0.19	–0.02	0.63	–0.08	0.04	0.74	–0.07
ASI13	0.48	0.03	0.08	0.49	–0.01	–0.04	0.53	0.07
ASI14	0.57	–0.09	0.05	0.71	0.07	–0.14	0.69	0.10
ASI15	0.60	0.38	0.06	0.46	–0.24	0.11	0.67	–0.08
ASI16	0.65	0.23	0.15	0.52	–0.15	0.03	0.68	0.06
PCS1	0.69	0.00	0.62	0.11	0.11	0.03	0.14	0.63
PCS2	0.69	0.24	0.57	0.09	–0.14	0.07	0.27	0.46
PCS3	0.70	0.03	0.83	0.07	–0.16	–0.14	0.25	0.72
PCS4	0.72	–0.02	0.83	0.04	–0.01	–0.08	0.13	0.79
PCS5	0.71	–0.04	0.89	–0.01	–0.02	–0.10	0.09	0.84
PCS6	0.70	0.03	0.70	0.06	0.04	0.00	0.13	0.68
PCS7	0.60	0.28	0.42	0.07	–0.12	0.13	0.24	0.32
PCS8	0.69	0.05	0.67	–0.06	0.17	0.13	–0.05	0.71
PCS9	0.73	–0.08	0.86	–0.07	0.18	0.01	–0.08	0.91
PCS10	0.74	–0.08	0.81	–0.05	0.23	0.05	–0.08	0.88
PCS11	0.72	–0.04	0.77	–0.13	0.29	0.14	–0.18	0.86
PCS12	0.61	0.03	0.77	–0.07	–0.03	–0.04	0.03	0.72
PCS13	0.73	0.23	0.50	0.16	–0.05	0.13	0.29	0.43
PASS1	0.65	0.14	0.09	0.11	0.56	0.50	–0.07	0.29
PASS2	0.69	0.05	0.13	0.12	0.69	0.50	–0.12	0.37
PASS3	0.73	0.15	0.15	0.04	0.69	0.60	–0.12	0.38
PASS4	0.69	0.02	0.16	0.11	0.71	0.49	–0.13	0.43
PASS5	0.77	0.35	–0.01	0.24	0.43	0.59	0.15	0.12
PASS6	0.55	0.49	–0.20	0.06	0.38	0.71	–0.01	–0.10
PASS7	0.59	0.56	–0.11	–0.10	0.42	0.82	–0.16	–0.01
PASS8	0.50	0.40	–0.01	–0.10	0.37	0.63	–0.17	0.09
PASS9	0.69	0.63	–0.09	–0.08	0.42	0.88	–0.13	–0.00
PASS10	0.54	0.46	–0.13	–0.01	0.40	0.69	–0.09	–0.02
PASS11	0.79	0.61	0.12	0.08	0.13	0.62	0.18	0.09
PASS12	0.84	0.66	0.08	0.12	0.13	0.67	0.23	0.04
PASS13	0.79	0.63	–0.04	0.12	0.15	0.65	0.28	–0.05
PASS14	0.77	0.69	–0.03	0.04	0.24	0.79	0.09	–0.03
PASS15	0.80	0.75	0.09	0.11	–0.04	0.61	0.31	–0.02
PASS16	0.78	0.87	0.05	–0.01	–0.04	0.73	0.21	–0.07
PASS17	0.74	0.81	0.08	–0.08	0.03	0.73	0.10	–0.01
PASS18	0.72	0.91	–0.00	–0.10	0.01	0.81	0.10	–0.11
PASS19	0.60	0.75	0.02	–0.12	0.10	0.75	–0.07	–0.03
PASS20	0.75	0.79	0.09	–0.14	0.13	0.80	–0.01	0.04

Items: ASI Anxiety Sensitivity Index; PASS Pain Anxiety Symptoms Scale, short form; PCS Pain Catastrophizing Scale

TABLE 7
Schmid-Leiman hierarchical factor model

	Second-order factor (G)	First-order factors (F1, F2 and F3)		
Item	Sensitivity to pain traumatization	F1 (pain anxiety)	F2 (anxiety sensitivity)	F3 (pain catastrophzing)
ASI1	0.12	0.01	0.01	–0.01
ASI2	0.57	0.09	0.47	–0.11
ASI3	0.48	–0.04	0.037	0.06
ASI4	0.41	–0.03	0.33	0.04
ASI5	0.15	–0.02	0.13	0.01
ASI6	0.50	–0.07	0.45	0.04
ASI7	0.43	0.06	0.33	–0.04
ASI8	0.48	0.01	0.40	–0.02
ASI9	0.52	–0.08	0.47	0.05
ASI10	0.55	–0.06	0.42	0.09
ASI11	0.56	0.01	0.45	0.00
ASI12	0.55	0.02	0.47	–0.04
ASI13	0.44	–0.02	0.34	0.04
ASI14	0.53	–0.06	0.44	0.06
ASI15	0.56	0.06	0.42	–0.05
ASI16	0.60	0.02	0.43	0.04
PCS1	0.64	0.02	0.09	0.37
PCS2	0.64	0.04	0.17	0.27
PCS3	0.65	–0.07	0.15	0.42
PCS4	0.67	–0.05	0.08	0.47
PCS5	0.67	–0.05	0.06	0.50
PCS6	0.65	0.00	0.08	0.40
PCS7	0.55	0.07	0.15	0.19
PCS8	0.64	0.07	–0.03	0.42
PCS9	0.68	0.00	–0.05	0.54
PCS10	0.69	0.03	–0.05	0.52
PCS11	0.67	0.08	–0.11	0.51
PCS12	0.57	–0.02	0.02	0.42
PCS13	0.68	0.07	0.18	0.25
PASS1	0.60	0.27	–0.04	0.17
PASS2	0.63	0.27	–0.07	0.22
PASS3	0.68	0.33	–0.11	0.23
PASS4	0.64	0.27	–0.08	0.24
PASS5	0.71	0.32	0.10	0.07
PASS6	0.50	0.39	–0.01	–0.01
PASS7	0.55	0.44	–0.10	–0.01
PASS8	0.47	0.34	–0.11	0.05
PASS9	0.64	0.48	–0.08	–0.00
PASS10	0.50	0.38	–0.06	–0.01
PASS11	0.73	0.34	0.11	0.05
PASS12	0.77	0.36	0.15	0.03
PASS13	0.72	0.36	0.18	–0.03
PASS14	0.71	0.43	0.06	–0.02
PASS15	0.74	0.33	0.20	–0.01
PASS16	0.72	0.40	0.13	–0.04
PASS17	0.68	0.40	0.07	–0.01
PASS18	0.67	0.44	0.06	–0.06
PASS19	0.55	0.41	0.013	–0.12
PASS20	0.69	0.44	–0.01	0.02
% variance explained	68.3	11.1	10.8	9.8

Items: ASI Anxiety Sensitivity Index; PASS Pain Anxiety Symptoms Scale, short form; PCS Pain Catastrophizing Scale

factor. The remaining items from the PASS-20, the PCS and the ASI had high loadings on the higher-order factor G. Moreover, loadings of all 47 items were higher on Factor G than on any of the three first-order factors, suggesting that they are more strongly related to the former than the latter. Notably, 20 items (ASI3, ASI4, ASI7, ASI13, PCS1, PCS2, PCS7, PCS13, PASS1 to PASS6, PASS8, PASS10 to PASS13, and PASS15) did not have significant (greater than 0.4)

loadings on any of the first-order factors in the SLT, whereas all 20 loaded significantly on the general higher-order Factor G. These 20 items, therefore, appear to directly represent the higher-order factor and are not considered to be 'good' measures of their first-order factors (32). An examination of the individual items suggests that this higher-order factor might be conceptualized as sensitivity to pain traumatization (SPT) given that the items appear to reflect anxiety-related somatic, cognitive, emotional and behavioural responses to pain that resemble symptoms of a traumatic stress reaction.

Table 8 demonstrates how the 20 SPT items (ie, those that loaded significantly on the SPT factor but not the first-order factors) can be categorized into three main symptom clusters characteristic of traumatic stress reactions of intense fear and a sense of helplessness:

- Re-experiencing in the form of intrusive thoughts about pain, intense psychological distress and physiological reactions.
- Behavioural avoidance and escape.
- Increased arousal including concentration difficulties and hypervigilance.

TABLE 8
Possible classification of the 20 sensitivity to pain traumatization items from the Anxiety Sensitivity Index (ASI), Pain Catastrophizing Scale (PCS) and Pain Anxiety Symptoms Scale, short form (PASS-20) into three post-traumatic stress disorder symptom clusters and an 'other' group

Experiencing/re-experiencing cluster
Intrusive thoughts
PCS1 – I worry all the time about whether the pain will end
PCS7 – I keep thinking of other painful events
PCS13 – I wonder whether something serious may happen
PASS3 – When I hurt I think about the pain constantly
PASS11 – I think that if my pain gets too severe, it will never decrease
Intense psychological distress
ASI3 – It scares me when I feel 'shaky' (trembling)
ASI4 – It scares me when I feel faint
PASS5 – I worry when I am in pain
PASS12 – When I feel pain I am afraid that something terrible will happen
PASS13 – When I feel pain I think that I might be seriously ill
PASS15 – When pain comes on strong I think that I might become paralyzed or more disabled
Avoidance cluster
Behavioural avoidance
PASS6 – I go immediately to bed when I feel severe pain
PASS8 – As soon as pain comes on I take medication to reduce it
PASS10 – I try to avoid activities that cause pain
Increased arousal cluster
Difficulty concentrating
PASS1 – I can't think straight when in pain
PASS4 – I find it hard to concentrate when I hurt
Hypervigilence
PASS2 – During painful episodes it is difficult for me to think of anything besides the pain
Other
PCS2 – I feel I can't go on
ASI7 – It embarrasses me when my stomach growls
ASI13 – Other people notice when I feel shaky

Testing the construct validity of SPT

The total score based on the 20 SPT items was calculated by adding responses to items ASI3, ASI4, ASI7, ASI13, PCS1, PCS2, PCS7, PCS13, PASS1 to PASS6, PASS8, PASS10 to PASS13, and PASS15. To examine the validity of the proposed SPT construct, the total SPT score of all items loading on the final factor solution for each group (P and NP) was correlated with the total score on the PCL-C (42). The resulting correlations show strong positive relationships between the PCL-C total score and the total score of the hypothesized higher-order factor for both Group P ($r=0.488$, $P<0.001$) and Group NP ($r=0.484$, $P<0.001$), providing initial support (ie, convergent validity) for the suggestion that an SPT construct represents the higher-order factor. The concurrent validity of the SPT construct was evaluated by comparing the mean SPT score between Groups P and NP. The total score on SPT was significantly higher for Group P ($t[419]=2.28$, $P=0.02$).

Finally, the total SPT score before surgery distinguished between Groups PP and NPP at the one-year follow-up ($t[288]=2.27$, $P=0.02$). That is, preoperative SPT scores were significantly higher for patients who reported persistent pain compared with those who were pain free at the one-year follow-up. In contrast, the total score on the PCL-C before surgery did not differ significantly between Group PP and Group NPP ($t[288]=1.44$, $P=0.15$). The finding that presurgery SPT scores, but not presurgery PCL-C scores were significantly higher in Group PP on one-year follow-up suggests that SPT taps a pain-specific traumatization construct rather than a general traumatization construct. These results provide preliminary evidence for the concurrent validity of the SPT construct.

DISCUSSION

The results of the present study demonstrate that with respect to the underlying factor structure of the PASS-20, the PCS and the ASI, a one-factor higher-order solution provided the best fit to the data. This factor included 20 items and explained 68.3% of the variance. The present results support previous research suggesting the existence of a single underlying fundamental factor involving "fear of pain or somatic sensations" (22,56).

Examination of the content of the 20 items loading on this underlying factor reveals that they represent multiple aspects of pain experience that are not limited to the specific constructs of pain anxiety, pain catastrophizing or anxiety sensitivity. Moreover, the SLT findings that these 20 items had higher loadings on the general factor than on the domain-specific factors suggests that they are a better representation of the higher-order factor than the corresponding first-order constructs (ie, pain anxiety, pain catastrophizing and anxiety sensitivity). At the same time, the underlying factor had a strong positive correlation with the total score on the PCL-C, suggesting features in common with traumatic stress reactions. We conceptualize this factor as SPT, which describes the propensity to develop anxiety-related somatic, cognitive, emotional and behavioural responses to pain that resemble features of a traumatic stress reaction. The categorization, in Table 8, of the 20 SPT items into the three symptom clusters associated with traumatic stress reactions is, obviously, incomplete. First, not all items fit into the three symptom clusters. Items ASI3 ("It scares me when I feel 'shaky' [trembling]") and ASI7 ("It embarrasses me when my stomach growls") introduce the question of whether SPT involves a social aspect, possibly involving fear of negative evaluation or some other aspect. Although item PCS2 ("I feel I can't go on") does not fall into one of the three symptom clusters, it is consistent with the DSM-IV A_2 criterion, which includes helplessness as one reaction to the traumatic stressor; in this case, pain itself. Second, because the PASS-20, the PCS and the ASI were not designed to measure pain as a traumatic stress reaction, the content overlap with such reactions is not complete and, therefore, there are symptoms that are not represented including, but not limited to, re-experiencing symptoms such as distressing pain-related dreams, symptoms of emotional numbing (pain-related emotional detachment, restricted affect or foreshortened future) and symptoms of hyperarousal (pain-related sleep disturbances, problems with emotion regulation and startle reactions). A questionnaire specifically designed to measure SPT would include additional items currently not tapped by the three questionnaires used in the present study.

An important point to emphasize is that the construct of SPT is not equivalent to PTSD. The finding that the presurgery total SPT

score, but not the presurgery PCL-C score, was significantly higher in Group PP versus Group NPP at the one-year follow-up further supports the construct overlap, but not identity, between SPT and PTSD/PTSS. Although both involve traumatic stress reactions, SPT defines a sensitivity (ie, propensity) to develop pain traumatization. The development of pain traumatization depends in part on the pain and traumatic histories of the individuals. Pain itself is conceptualized as a potential traumatic stressor no matter whether a previous painful, traumatic event has occurred. Thus, we are not suggesting that patients who score high on SPT necessarily have been traumatized by a specific painful and traumatic event, but that they are at a higher risk of becoming traumatized should they be exposed to a painful injury or surgery.

The SPT construct is consistent with the suggestion that pain not only causes anxiety – it also often represents a traumatic stressor itself (13). Recent diathesis-stress (57) and fear/anxiety-avoidance (7,8) models propose that various aspects of fear and anxiety (anxiety sensitivity, catastrophizing and pain avoidance) serve both as predisposing and maintaining factors for chronic pain. Consistent with these models, we suggest that the overall level of SPT, which encompasses the fear- and anxiety-related somatic, cognitive, emotional and behavioural (and, possibly, social concerns) reactions to pain, may be a broad-based vulnerability factor and a maintaining factor for the transition to pain chronicity.

When pain experiences lead to pain traumatization, we would expect the person to develop chronic pain and pain disability. Different aspects of the SPT construct (pain rumination/catastrophizing, psychological distress and intense physiological reactions to painful sensations, physiological anxiety, pain avoidance, helplessness, physiological arousal and worry regarding negative consequences of persistent pain) would affect the quality and the course of the individual experience. However, only the cumulative effect of these various features representing global pain traumatization would define the development and maintenance of chronic pain. In other words, SPT is believed to be a dimensional construct and a high level of pain traumatization could, in different individuals, reflect various combinations of specific somatic, cognitive, affective and behavioural symptoms. As noted above, such a hierarchical structure suggests that SPT may represent a vulnerability factor for the development of chronic pain. It may serve as a predisposing factor that triggers specific expressions of pain, such as pain catastrophizing, physiological anxiety and avoidance, which have differential/specific impacts on the quality of pain experience, as well as maintenance of pain.

The present study has several limitations that warrant consideration and provide direction for future research. First, only self-report measures were used to evaluate each of the anxiety-related constructs, making cross-validation impossible, risking artificial inflation of correlations due to method invariance among measures and artificial inflation of internal consistency within the measures. That is, the self-report measures were grouped and presented in their original questionnaire formats; future studies should vary presentation format (eg, common item presentation but in random order) to evaluate the strength of these results. Furthermore, the sample size was insufficient for a complementary confirmatory factor analysis of hierarchical factor structure of anxiety-related constructs.

Second, the relationships among anxiety-related constructs may be different when evaluated with other samples (eg, nonclinical population or clinical population with and without chronic pain condition, but not requiring major surgery). Until these other groups have been assessed, the generalizability of the present results is limited. Evaluation with nonclinical samples is particularly critical because several previous studies found significant differences in the pattern of pain-related and anxiety-related constructs, and because SPT involves a sensitivity or propensity to develop pain traumatization, which is expected to be present in various degrees in the normal population.

Finally, while the PCS, the PASS-20 and the ASI contain items that tap the broad symptom clusters associated with traumatic stress reactions (re-experiencing or experiencing pain, avoidance and hyperarousal), these scales do not contain items that measure emotional numbing – an important component of traumatic stress reactions and one that seems particularly relevant to pain (58-60).

CONCLUSION

Current research in the psychology of pain is devoted to the investigation of various pain-related anxiety constructs, usually in isolation, and their contribution to the maintenance and exacerbation of pain. Although there have been some attempts to integrate these pain-related anxiety constructs, research in this area is sparse. Moreover, even fewer studies have investigated the possible hierarchical structure of pain-related constructs. There is an emerging hypothesis that most pain-related anxiety constructs are derived from an underlying, higher-order, fundamental fear; however, currently, the exact nature of this fear remains to be determined (22,56). This uncertainty stems, in part, from a lack of empirical research probing this intriguing hypothesis. The results of the present study advance the understanding of the underlying mechanism(s) and structure of pain-related anxiety, and may contribute to the development of more efficient treatments for pain and, ultimately, the prevention of chronic pain.

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