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The Central Sensitization Inventory and Pain Sensitivity Questionnaire: An Exploration of Construct Validity and Associations with Widespread Pain Sensitivity among Individuals with Shoulder Pain

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INTRODUCTION

Central sensitization (CS) is a complex phenomenon associated with amplified central nervous system signaling and enhanced pain sensitivity (Woolf, 2011). CS has been linked with fibromyalgia, chronic fatigue syndrome, and temporomandibular disorder (La Touche et al., 2017, Meeus and Nijs, 2007, Yunus, 2007). Additionally, this phenomenon has also been associated with common localized musculoskeletal conditions, such as low back, shoulder, and knee pain (Lluch et al., 2014, Roussel et al., 2013, Sanchis et al., 2015). The mechanisms of CS leading to an enhanced pain state can involve multiple processes such as spinal cord hyperexcitability (Price et al., 2002) and ascending/descending modulatory systems (Tracey and Mantyh, 2007). Direct determination of CS cannot be made in humans, but common procedures for inferring CS – through alterations in pain sensitivity – involve quantitative sensory tests (QST) (Arendt-Nielsen and Yarnitsky, 2009). For example, features of CS include lowered pain thresholds and elevated pain ratings to standardized stimuli local to the primary area of pain and at remote regions (e.g., widespread pain sensitivity) (Latremoliere and Woolf, 2009, Lee et al., 2011). While the evidence on the clinical significance of altered pain sensitivity is mixed (Hubscher et al., 2013, Marcuzzi et al., 2016, Slade et al., 2016), some studies suggest pain sensitivity is an important determinant of patient-reported outcome and a potential factor guiding treatment response (Penza et al., 2017, Sterling et al., 2003).

QST often involves specialized equipment, training, and time (Rolke et al., 2006). These testing features allow for comprehensive evaluation of multiple stimulus modalities and determination of pain sensitivity profiles, including patterns of widespread pain sensitivity suggestive of CS (Coronado et al., 2014a, Cruz-Almeida et al., 2013, Frey-Law et al., 2016).

Self-report questionnaires offer an alternative to QST with potential clinical advantages. Self-report questionnaires can be easily administered to large clinical samples, embedded within electronic health records, and are free from the necessity of advanced training. However, these self-report tools should demonstrate reasonable associations with QST to support their construct validity for inferring CS.

Two existing questionnaires, the Central Sensitization Inventory (CSI) (Mayer et al., 2012) and Pain Sensitivity Questionnaire (PSQ) (Ruscheweyh et al., 2009), have been developed to assist in the identification of CS and/or elevated pain sensitivity. The CSI is a broad assessment tool measuring comorbid complaints and conditions related to “central sensitivity syndromes.” However, to date, only one study has examined the construct validity between the CSI and QST (Caumo et al., 2017). Caumo et al. (2017) compared CSI scores to a conditioned pain modulation test and found higher CSI scores in patients with impaired descending pain modulation compared to those with normal responses. The PSQ has shown associations to a variety of QST, including pain threshold and suprathreshold responses, in healthy individuals and patients with chronic pain conditions (Ruscheweyh et al., 2009, Ruscheweyh et al., 2012, Sellers et al., 2013, Valeberg et al., 2017). Beyond their individual correlation with pain sensitivity tests, there have not been attempts to explore whether the CSI or PSQ can differentiate patients with meaningful QST patterns that may suggest CS, such as widespread pain sensitivity.

The primary objective of this study was to explore the comparative validity of the CSI and PSQ with QST (construct validity) and established pain-related psychological questionnaires (concurrent validity). We hypothesized the PSQ and CSI would demonstrate moderate correlations with QST and psychological questionnaires. A secondary objective was to explore the associations between the CSI, PSQ, and pain-related psychological questionnaires with a clinical pattern of widespread pain sensitivity. The results of this study can inform on the validity and utility of the CSI and PSQ as self-report tools for inferring pain sensitivity patterns consistent with CS.

MATERIALS AND METHODS

Study Design

This is a secondary analysis of cross-sectional data obtained from a prospective randomized controlled trial. The reporting of this data followed guidelines from the Strengthening the Reporting of Observational Studies in Epidemiology statement (von Elm et al., 2007).

Setting and Study Procedures

This study was conducted at an academic medical center on the campus of the University of Florida. After obtaining written informed consent, participants completed a standardized survey (age, sex, education, pain duration) and a battery of validated questionnaires. Following the self-report assessment, participants underwent QST. Study procedures were approved by the University of Florida’s Institutional Review Board.

Participants

Participants were enrolled in a randomized controlled trial of conservative intervention on pain sensitivity (Coronado et al., 2015). Eligible participants were English-speaking, aged 18 to 65 years, with unilateral shoulder pain of less than 6 months and current pain at the moment of at least 4/10 on a Numeric Rating Scale. Individuals were excluded if they: 1.) were in physical therapy for shoulder pain, 2.) had neck pain or shoulder instability, 3.) had undergone neck or shoulder surgery, 4.) had shoulder pain as a result of traumatic injury or related to diagnosis of adhesive capsulitis or fracture, 5.) had a past or present serious medical condition, 6.) demonstrated signs of cervical nerve root involvement (e.g., motor weakness, hyporeflexia, or sensory disturbance), or 7.) had contraindications for manipulative therapy. Participants without shoulder pain were enrolled as an age and sex-matched comparison group to determine enhanced widespread pain sensitivity in the shoulder pain group. These individuals were excluded if they: 1.) had upper extremity neurological impairments, 2.) were taking pain medication, or 3.) had a previous history of shoulder surgery.

The sociodemographic characteristics of the study participants have been previously described (Coronado et al., 2015). The sample included 78 participants with shoulder pain (mean $\pm$ SD age = 39.0 ± 14.5 years, N (%) females = 36 (46.2%), mean $\pm$ SD pain duration = 20.7 ± 36.2 weeks) and 25 participants without shoulder pain (N = 25, mean $\pm$ SD age = 35.2 ± 11.1 year, N (%) females = 13 (52.0%)). At baseline, there were no sociodemographic differences between cohorts (Coronado et al., 2015). Only baseline data of participants is included in the current analyses.

Self-Reported Pain Sensitization Measures

Central Sensitization Inventory (CSI)—The CSI is a two-part questionnaire that contains a 25-item survey (Part A) that assesses the frequency of health-related symptoms associated with central sensitivity syndromes and a brief survey (Part B) asking if patients have been diagnosed with specific disorders (Neblett et al., 2013). For the purposes of this study, only responses from the 25-item survey were included. Participants are asked to rate each question on a 5-point scale with 0 meaning “never” and 4 meaning “always.” A summed response is obtained with a total possible score of 100. Higher CSI scores represent greater self-reported symptomology. A cutoff score of 40 or greater has shown acceptable psychometrics for identifying patients with central sensitivity syndromes (Neblett et al., 2013) and has been recommended in guidelines for pain mechanism classification (Nijs et al., 2015). The CSI has excellent test-retest reliability and internal consistency and has shown moderate correlation to psychological and condition-specific measures (Kim et al., 2015, Kregel et al., 2016, Mayer et al., 2012, Neblett et al., 2013, Scerbo et al., 2017). Recent work by Cuesta-Vargas et al. (2018) supports a unidimensional factor structure and the appropriateness of using a single summed CSI score for analyses.

Pain Sensitivity Questionnaire (PSQ)—The PSQ is a 17-item questionnaire that assesses a patient’s perception to various imagined physical stimuli that may be experienced in daily life (Ruscheweyh et al., 2009). Participants are asked to rate the pain intensity of each situational item on a 11-point scale with 0 meaning “not painful at all” and 10 meaning

“worst pain imaginable.” Three items (items 5, 9, and 13) are not normally rated as painful and are not included in scoring. Two scores are obtained from the PSQ. The PSQ-total score is the average of all items, except for the three non-painful items. The PSQ-minor score is the average of items 3, 6, 7, 10, 11, 12, and 14 – items, on average, that are perceived as causing minor pain. The PSQ is a reliable and valid measure (Azimi et al., 2016, Kim et al., 2014, Ruscheweyh et al., 2009). PSQ-total and PSQ-minor scores have shown low to moderate correlation with psychological measures and moderate correlation with QST pain intensity ratings in healthy individuals (Ruscheweyh et al., 2012). In patients with chronic localized pain, PSQ-total and PSQ-minor scores have shown stronger correlations to QST compared to those found in healthy individuals (Ruscheweyh et al., 2012).

Quantitative Sensory Testing

QST was conducted following a standardized protocol for pressure pain threshold (PPT), heat pain threshold (HPT), and suprathreshold heat pain rating (SHPR). All measurements were conducted bilaterally, commencing with the right side and alternating between sides, when indicated, to avoid pain habituation or summation. Previous investigations have used a similar QST protocol for test performance and anatomical regions assessed (Coronado et al., 2014b, Valencia et al., 2011). Currently, there is no universally accepted QST protocol for evaluating pain sensitivity, but standards for conducting QST have been proposed (Backonja et al., 2013, Rolke et al., 2006). In general, QST procedures have demonstrated good reliability (Backonja et al., 2013, Marcuzzi et al., 2017), but depend on patient responses that may be influenced by factors such as attention and motivation. QST is a valid form of assessment for sensory hyperfunction, including hyperalgesia and allodynia (Arendt-Nielsen and Yarnitsky, 2009, Backonja et al., 2013, Pavlakovic and Petzke, 2010).

Pressure Pain Threshold (PPT)—PPTs were assessed by a trained examiner using a hand-held pressure digital algometer with a 1-cm²-diameter probe (Wagner Instruments, Inc., Greenwich, CT). A mechanical force was applied to the participant’s skin at a target rate of 1 kg/second until the participant reported the first moment of pain. The amount of pressure, in kilograms, was recorded. Measurements were taken at the tip of the affected or dominant side acromion, bilateral masseter muscle belly, and bilateral tibialis anterior muscle belly. A total of 3 measurements were collected at each site per side rotating between each side to avoid pain habituation or summation. The average of trials was used in these analyses.

Heat Pain Threshold—Heat pain thresholds were assessed at the anterior forearm using a 30 × 30 mm thermode connected to a PATHWAY Model Advanced Thermal Stimulator (Medoc Advanced Medical Systems, Ramat Yishai, Israel). A standard heat stimulus with a steady temperature increase (0.5°C/s) was initiated and participants were instructed to report the first moment of pain. Once indicated, the temperature (°C) and pain rating associated with the heat pain threshold was recorded. Participants rated the pain intensity associated with the heat pain threshold on a 101-point numeric rating scale with 0 meaning “no pain” and 100 meaning “worst pain imaginable.” A total of two measurements were collected on each side rotating between sides to avoid habituation or summation. The average of trials was used in these analyses.

Suprathreshold Heat Pain Rating—A suprathreshold heat pain rating was assessed at the anterior forearm using a contact thermode with 2.5 cm² surface areas connected to a PATHWAY Model Contact Heat Evoked Potential Stimulator (CHEPS) (Medoc Advanced Medical Systems, Ramat Yishai, Israel). Five consecutive heat pulses with peak temperature of 46°C were applied at a rate of 30°C per second and an interstimulus interval of 2.5 seconds. Participants were instructed to rate the pain intensity associated with each heat pulse on a 101-point numeric rating scale with 0 meaning “no pain” and 100 meaning “worst pain imaginable”. The suprathreshold heat pain rating was defined as the pain rating associated with the 5th heat pulse. A suprathreshold pain rating was assessed once on each side and the average of sides used in these analyses.

Psychological Measures

Brief Resilience Scale (BRS)—The BRS is a 6-item questionnaire that assesses an individual's ability to bounce back or recover from stress (Smith et al., 2008). Participants are asked to rate the extent to which they agree with items such as “I tend to bounce back quickly after hard times” and “I usually come through difficult times with little trouble” on a 5-point scale with scoring alternative ranging from “strongly disagree” to “strongly agree”. Three of the six items are reverse scored and an average score of the six items is obtained. The BRS has good internal consistency, is reliable, and is correlated to other validated resilience measures when tested in patients with and without musculoskeletal conditions (Windle et al., 2011). A unidimensional factor structure has been reported for the BRS (Smith et al., 2008).

Depression, Anxiety, and Stress Scale (DASS-21)—The DASS-21 is a 21-item questionnaire that assesses depression, anxiety, and stress symptoms (Henry and Crawford, 2005). Each construct subscale consists of 7 items. Participants rate each item on a 4-point scale with 0 meaning “Did not apply to me at all” and 3 meaning “Applied to me very much, or most of the time.” Items for each subscale are summed and multiplied by 2 to obtain a total subscale score. The DASS-21 is a reliable measure and demonstrates good discriminative validity for depression, anxiety, and stress (Antony et al., 1998, Henry and Crawford, 2005). The DASS-21 has high internal consistency, but subscale scores and individuals items show substantial correlation (Sinclair et al., 2012). While shared variance exists at the item and subscale level, confirmatory factor analyses have supported both a three-factor model as well as a general factor structure (Henry and Crawford, 2005, Osman et al., 2012, Sinclair et al., 2012).

Positive and Negative Affect Schedule (PANAS)—The PANAS is a 20-item scale that assesses positive and negative feelings and emotions (Watson et al., 1988). Participants are asked to rate the extent they generally feel interested, upset, enthusiastic, etc. Participants rate each word on a 5-point scale with 1 meaning “very slightly or not at all” and 5 meaning “extremely.” The PANAS contains a 10-item subscale representing positive and negative affect. PANAS subscale scores are obtained by summing each item for subscale scores ranging from 10 to 50. The PANAS is a reliable measure (Crawford and Henry, 2004, Schmukle et al., 2002) and both positive and negative scales show good convergent and discriminant validity (Watson et al., 1988). The factor structure of the PANAS has been

examined in multiple studies and variable support exists for an orthogonal, oblique, and more complex multidimensional structure (Crawford and Henry, 2004, Killgore, 2000, Leue and Beauducel, 2011, Watson et al., 1988). The core dimensions of both positive and negative affect have emerged in these studies and support the use of the two subscales.

Data Analysis

IBM SPSS Statistics for Windows, Version 22.0 (Armonk, NY: IBM Corp.) was used for analyses. Baseline descriptive statistics were generated for self-reported measures and QST. Distribution free tests were used for the primary analyses due to sample size and because normality assumptions were not met for bivariate associations and independent group comparisons. Spearman correlation was used to examine the relationship between self-reported pain sensitization, QST, and psychological measures. Correlation values less than 0.3 were interpreted as weak, between 0.3 and 0.5 were moderate, and greater than 0.5 were strong (Cohen, 1988). Widespread pain sensitivity was determined in the shoulder pain group using PPT values at the affected acromion, bilateral masseter, and bilateral tibialis anterior in comparison to sex-matched values in the participant group without shoulder pain. We used a similar approach in a previous paper to determine central sensitivity in patients seeking operative treatment for shoulder pain (Coronado et al., 2014b). PPT values within the shoulder pain group that were below the 10th percentile of sex-matched values in the “healthy” participants were used as an indicator for enhanced sensitivity at each anatomical site (Neziri et al., 2011). A strict composite index for widespread pain sensitivity was created based on enhanced local and remote pressure pain sensitivity across all three anatomical sites. Comparisons were made between the widespread and non-widespread pain sensitivity group for sociodemographic and self-report questionnaires using the Mann-Whitney U test. Univariable and multivariable odds ratios with 95% confidence intervals (CI) were computed using logistic regression for estimating effect size. Multivariable analyses accounted for age, sex, and education as *a-priori* confounders.

RESULTS

Baseline Scores of Participants

At baseline, the mean $\pm$ SD scores on the CSI, PSQ-total, and PSQ-minor were 30.5 ± 13.5 , 4.1 ± 1.8 , and 3.1 ± 1.8 in participants with shoulder pain, respectively (Table 1). The proportion of participants with central sensitivity on the CSI (e.g., scores > 40) was 24.4% ($n = 19$).

CSI and PSQ Associations with Quantitative Sensory Tests

Correlations between the CSI and pressure or heat pain thresholds ranged from -0.13 to -0.08 , but overall were not significant ($p > 0.05$) (Table 2). There was no association between the CSI and heat pain threshold pain ratings or suprathreshold heat pain rating ($p > 0.05$). PSQ-total scores were weakly associated with PPT at the masseter ($\rho = -0.27$, $p < 0.05$) and tibialis anterior ($\rho = -0.25$, $p < 0.05$). PSQ scores were not associated with PPT at the acromion, heat pain threshold, or suprathreshold values ($p > 0.05$).

CSI and PSQ Associations with Psychological Measures

The CSI was moderately associated with scores on the BRS ($\rho = -0.29$, $p < 0.05$), and strongly associated with DASS-21 subscales for depression, anxiety, and stress (range of $\rho = 0.64$ to 0.67 , $p < 0.05$) and with the negative affect subscale of the PANAS ($\rho = 0.67$, $p < 0.05$) (Table 3). The PSQ was moderately associated with the BRS (range of $\rho = -0.37$ and -0.39 , $p < 0.05$) and weak-to-moderately associated with the DASS-21 subscale for anxiety (range of $\rho = 0.25$ and 0.31 , $p < 0.05$) and the negative affect subscale of the PANAS (range of $\rho = 0.27$ and 0.31 , $p < 0.05$).

Self-Reported Measures and Widespread Pain Sensitivity

Nearly 30% ($n = 23$) of patients were identified as having widespread pain sensitivity when compared to the pain-free comparison participants (Table 4). Neither the PSQ nor CSI distinguished patients with widespread pain sensitivity compared to those who did not meet this criterion ($p > 0.05$). One measure, the BRS, showed significantly lower scores in participants with widespread pain sensitivity (adjusted OR = 0.41 (95% CI = 0.18; 0.94), $p < 0.05$) (Table 5). The positive affect subscale of the PANAS approached a significant difference between groups ($p = 0.07$). In multivariable analyses, participants with lower scores on the positive affect schedule of the PANAS were more likely to demonstrate widespread pain sensitivity (adjusted OR = 0.92 (95% CI = 0.86; 1.00), $p < 0.05$). Scores on the DASS-21 subscales for depression, anxiety, and stress and the negative affect subscale of the PANAS were not different between participants with or without widespread pain sensitivity ($p > 0.05$).

DISCUSSION

The validity of the CSI and PSQ were examined through associations with QST (construct validity) and psychological measures (concurrent validity). In regards to construct validity, only the PSQ was associated with remote PPT. However, this association was weak and likely to be of low clinical relevance. Our initial hypothesis that both measures would show moderate correlation with QST was not supported. In contrast, the CSI and PSQ more consistently demonstrated concurrent validity with psychological factors and, in some cases, the correlations were quite strong (e.g. CSI and depressive symptoms). This was in line with our initial hypothesis that both measures would be correlated with psychological measures, but the magnitude of the association of the CSI with specific measures was stronger than expected. This finding suggests it could be hard clinically to isolate pain sensitivity via self-report. When further exploring which measures were associated with presence of widespread pain sensitivity – a common proxy for CS – neither the CSI nor the PSQ showed an association. Instead, resilience was the strongest associated factor in participants with shoulder pain and widespread pain sensitivity.

The construct validity of the PSQ with QST has been previously examined. Significant correlations of varying magnitude have been noted between the PSQ and a range of pain sensitivity measures including threshold and suprathreshold responses (Quan et al., 2017, Ruscheweyh et al., 2009, Ruscheweyh et al., 2012, Sellers et al., 2013, Valeberg et al., 2017). In the original paper by Ruscheweyh et al. (2009), weak non-significant associations

were found between PSQ scores and pain thresholds (e.g., amount of pressure or heat) in healthy individuals. However, in patients with chronic pain, weak to moderate associations (range of r from -0.29 to -0.57) were observed with pain thresholds at remote anatomical regions to the primary pain area (Ruscheweyh et al., 2012). Similarly, Larsson et al. (2017) reported an association between PSQ-total scores and spreading of pain, suggesting a potential relationship to remote pain sensitivity. These findings are similar to the current study, where relatively stronger associations, albeit weak in magnitude, were found between PSQ-total scores and remote PPT. More notably, several authors have reported greater associations between the PSQ and pain intensity ratings at pain threshold (Quan et al., 2017, Ruscheweyh et al., 2009, Ruscheweyh et al., 2012), with correlations as high as 0.7. We did not examine PPT pain intensity, but did assess pain intensity with heat pain thresholds and did not find significant associations. Surprisingly, the PSQ did not distinguish patients with a clinical pattern of remote sensitization (e.g., widespread pain sensitivity), and this finding challenges the utility of the PSQ for inferring a more general sensitization state. More work is needed to determine whether the PSQ can detect pain sensitization profiles using alternative methods (i.e., empirically-derived) in patients at risk for chronic pain.

The construct validity of the CSI with QST has not been widely examined. The findings from the current study and that of Caumo et al. (2017) are conflicting, but are likely due to the manner in which patients were subgrouped. In the current study, threshold measures, as opposed to a dynamic paradigm, were used to characterize patients based on *a-priori* criterion. These different QST parameters are thought to provide distinct information regarding nervous system processing of pain and perhaps explain the difference in findings. While prior studies have shown associations between the CSI and PSQ with psychological distress (Ruscheweyh et al., 2012, Scerbo et al., 2017, Sellers et al., 2013, van Wilgen et al., 2017), no prior study has examined the relationship of either the CSI or PSQ to positive psychological factors. We observed that these measures were negatively associated with resilience – a potential combatting factor to pain vulnerability. Interestingly, resilience was also associated with widespread pain sensitivity. There is preliminary evidence suggesting resilience may be a protective factor for experimental pain response (Friborg et al., 2006, Smith et al., 2009). Additionally, a growing body of work is focusing on the role resilience may play in chronic pain patients (Ankawi et al., 2017, Finan and Garland, 2015, Sturgeon and Zautra, 2010). These findings may highlight the role of positive psychological factors as important protective elements of pain sensitization.

Potential Clinical Implications

The identification of CS in clinical practice has been encouraged for targeting pain mechanisms. Since QST are often used to infer nervous system processing alterations, clinical tools should show reasonable associations with these standards. Based on the current study, the clinical use of self-reported measures for inferring pain sensitization should be challenged. Perhaps a stronger approach to determining CS is the combination of established psychological measures with clinically-feasible QST assessment (Osgood et al., 2015). This recommendation is based on several factors, namely 1.) the importance of multidimensional pain assessment, 2.) the observed overlap in psychological measures with the CSI and PSQ,

and 3.) the necessity of using pragmatic QST paradigms that directly provide the requisite pain sensitization insight.

In this cohort, resilience distinguished patients with and without widespread pain sensitivity. Theoretically patients with high levels of resilience may be less likely to develop CS (or vice versa), but positive psychological constructs have not been studied extensively in combination with QST. Future investigation in this area is needed and it could be a compelling paradigm where subgroups are created based on self-report measures of psychological vulnerability and resilience and pragmatic QST approaches.

Limitations

We did not include a sample of patients representative of chronic widespread pain. Rather, we were intent on a sample of patients with a common condition where these questionnaires could be used to screen for CS involvement. Additionally, the included sample is a subgroup of patients with shoulder pain meeting specific inclusion criteria for a randomized trial and this limits generalizability. Further work in a broader representative sample is needed to confirm these findings. The QST battery was not exhaustive and including pressure and heat modalities only. Prior work on the PSQ has involved cold (Ruscheweyh et al., 2009), chemical (Sellers et al., 2013), and electrical stimuli (Quan et al., 2017) and thus, we cannot directly compare our results to these methods, nor can we directly compare to the CSI work involving conditioned pain modulation (Caumo et al., 2017). The exploration of associations between the CSI and PSQ with widespread pain sensitivity is limited to the manner in which this sensitization pattern was conceptualized and defined. In this study, we used a strict composite PPT index (Coronado et al., 2014b) and there are likely additional ways to develop a pattern suggestive of CS. Additionally, we examined two specific questionnaires that have been developed for identifying pain sensitization. However, there are other questionnaires available for assessing nervous system sensitivity including the Sensory Hypersensitivity Scale (Dixon et al., 2016). Also lacking in this study was a longitudinal aspect, which precludes assessment of the temporal relationship between the included measures.

Conclusion

We explored associations between the CSI and PSQ with measures of pain sensitivity (construct validity), established psychological measures (concurrent validity), and the presence of widespread pain sensitivity. The results of this study provide preliminary evidence challenging the exclusive use of the CSI or PSQ for inferring central sensitization as there was weak relationship with pain sensitivity, significant overlap with psychological constructs, and inability to distinguish widespread pain sensitivity. Future efforts are needed for further developing clinical frameworks that use QST to identify CS and to further elucidate the role resilience factors play in developing of widespread pain sensitivity.

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Table 1.

Baseline self-reported pain sensitization, quantitative sensory test, and psychological values of participants with shoulder pain (N = 78).

Measure	Mean $\pm$ SD
<i>Pain Sensitization – Self-Report</i>	
Central sensitization (CSI)	30.5 $\pm$ 13.5
Pain sensitivity (PSQ, total)	4.1 $\pm$ 1.8
Pain sensitivity (PSQ, minor)	3.1 $\pm$ 1.8
<i>Pain Sensitization – Quantitative Sensory</i>	
Pressure pain threshold – acromion (in kg)	3.1 $\pm$ 1.6
Pressure pain threshold – masseter (in kg)	1.4 $\pm$ 0.6
Pressure pain threshold – tibialis anterior (in kg)	5.2 $\pm$ 2.4
Heat pain threshold – temperature (in °C)	42.6 $\pm$ 1.9
Heat pain threshold – pain rating (x/100)	36.4 $\pm$ 22.9
Suprathreshold heat pain response (x/100)	43.0 $\pm$ 25.7
<i>Psychological – Positive</i>	
Resilience (BRS)	3.7 $\pm$ 0.7
Positive affect (PANAS)	33.8 $\pm$ 7.6
<i>Psychological – Negative</i>	
Depression (DASS-21)	6.1 $\pm$ 7.6
Anxiety (DASS-21)	5.1 $\pm$ 5.6
Stress (DASS-21)	10.6 $\pm$ 8.6
Negative affect (PANAS)	17.1 $\pm$ 7.3

Abbreviations: BRS = Brief Resilience Scale; CSI = Central Sensitization Inventory; DASS-21 = Depression Anxiety Stress Scale; PANAS = Positive and Negative Affect Schedule; PSQ = Pain Sensitivity Questionnaire

Correlations between self-report sensitization measures and quantitative sensory tests in participants with shoulder pain (N = 78)

Table 2.

Measure	Pressure Pain Threshold			Heat Pain Threshold		Suprathreshold Heat Pain Rating
	Acromion	Masseter	Tibialis	Temperature	Pain Rating	
Central sensitization (CSI)	-0.13	-0.09	-0.13	-0.08	0.13	-0.03
Pain sensitivity (PSQ, total)	-0.14	-0.27*	-0.25*	-0.17	0.17	0.15
Pain sensitivity (PSQ, minor)	-0.12	-0.17	-0.18	-0.10	0.12	0.06

Values are Spearman correlation coefficients

Abbreviations: CSI = Central Sensitization Inventory; PSQ = Pain Sensitivity Questionnaire; TA = Tibialis Anterior

* $p < 0.05$

Table 3.

Correlations between self-report sensitization and psychological measures in participants with shoulder pain (N = 78)

Measure	Positive Psychological Factors		Negative Psychological Factors			
	Resilience (BRS)	Positive Affect (PANAS)	Depression (DASS-21)	Anxiety (DASS-21)	Stress (DASS-21)	Negative Affect (PANAS)
Central sensitization (CSI)	-0.29*	-0.11	0.64*	0.66*	0.67*	0.67*
Pain sensitivity (PSQ, total)	-0.39*	-0.16	0.14	0.31*	0.14	0.31*
Pain sensitivity (PSQ, minor)	-0.37*	-0.17	0.12	0.25*	0.10	0.27*

Values are Spearman correlation coefficients

Abbreviations: BRS = Brief Resilience Scale; CSI = Central Sensitization Inventory; DASS-21 = Depression Anxiety Stress Scale; PANAS = Positive and Negative Affect Schedule; PSQ = Pain Sensitivity Questionnaire

* $p < 0.05$

Table 4.

Characteristics of participants with shoulder pain demonstrating widespread pain sensitivity (n = 23) and non-widespread pain sensitivity (n = 55).

Measure	Widespread pain sensitivity	No widespread pain sensitivity	p-value *
<i>Demographic</i>			
Age, in years	34.4 ± 15.1	41.0 ± 14.0	0.08
Sex, N (%) female	14 (60.0)	22 (40.0)	0.09
Education, N (%) high school or less	9 (39.1)	11 (20.0)	0.08
Pain duration, in weeks	22.6 ± 53.0	19.9 ± 26.8	0.82
<i>Pain Sensitization – Self-Report</i>			
Central sensitization (CSI)	31.7 ± 14.7	30.0 ± 13.0	0.64
Pain sensitivity (PSQ, total)	4.5 ± 1.9	3.9 ± 1.7	0.19
Pain sensitivity (PSQ, minor)	3.5 ± 2.0	3.0 ± 1.8	0.31
<i>Psychological – Positive</i>			
Resilience (BRS)	3.4 ± 0.8	3.9 ± 0.6	< 0.05
Positive affect (PANAS)	31.1 ± 8.9	35.0 ± 6.7	0.07
<i>Psychological – Negative</i>			
Depression (DASS-21)	7.1 ± 8.0	5.6 ± 7.5	0.44
Anxiety (DASS-21)	5.3 ± 5.9	5.0 ± 5.5	0.86
Stress (DASS-21)	11.6 ± 8.5	10.2 ± 8.7	0.52
Negative affect (PANAS)	18.3 ± 7.3	16.7 ± 7.4	0.39

Values are mean ± SD or N (%)

Abbreviations: BRS = Brief Resilience Scale; CSI = Central Sensitization Inventory; DASS-21 = Depression Anxiety Stress Scale; PANAS = Positive and Negative Affect Schedule; PSQ = Pain Sensitivity Questionnaire

* p-value based on Mann-Whitney U test

Table 5.

Unadjusted and adjusted odds ratios (OR) for self-report measures and the association with widespread pain sensitivity.

Measure	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)
<i>Pain Sensitization – Self-Report</i>		
Central sensitization (CSI)	1.01 (0.97; 1.05)	1.00 (0.97; 1.05)
Pain sensitivity (PSQ, total)	1.21 (0.92; 1.59)	1.17 (0.87; 1.57)
Pain sensitivity (PSQ, minor)	1.15 (0.89; 1.50)	1.09 (0.82; 1.46)
<i>Psychological – Positive</i>		
Resilience (BRS)	0.34 (0.16; 0.75)	0.41 (0.18; 0.94)
Positive affect (PANAS)	0.93 (0.87; 1.00)	0.92 (0.86; 1.00)
<i>Psychological – Negative</i>		
Depression (DASS-21)	1.03 (0.96; 1.09)	1.02 (0.95; 1.10)
Anxiety (DASS-21)	1.01 (0.92; 1.10)	1.00 (0.91; 1.11)
Stress (DASS-21)	1.02 (0.96; 1.08)	1.01 (0.95; 1.08)
Negative affect (PANAS)	1.03 (0.97; 1.10)	1.01 (0.94; 1.08)

Abbreviations: BRS = Brief Resilience Scale; CSI = Central Sensitization Inventory; DASS-21 = Depression Anxiety Stress Scale; PANAS = Positive and Negative Affect Schedule; PSQ = Pain Sensitivity Questionnaire

* Adjusted for age, sex, and education