Trait Sensitivity, Anxiety and Personality are predictive of Central Sensitisation Symptoms in Patients with Chronic Low Back Pain.

Clark J, Nijs J, Smart K, Holmes P, Yeowell G, Goodwin P.

Author contributions: All authors have contributed to the current study by co-designing the protocol, discussing the results and revising the manuscript.

Abstract

Background: Sensitivity-related trait characteristics involving physical and emotional sensitivities and high trait anxiety personality types have been observed in individuals with non-specific chronic low back pain (NSCLBP). High trait sensitivity to sensory stimulation combined with interpretation biases based on personality type may contribute to the development of central sensitisation (CS) symptoms. To date there is limited research that has considered both sensitivity levels and personality type in NSCLBP with CS. The purpose of this study was to investigate 1) relationships between trait sensory profiles, trait anxiety and CS symptoms, and 2) the predictive capacity of sensory profiles, trait anxiety and personality types on CS symptoms, in people with NSCLBP.

Methods: This was a cross-sectional observational study using four self-report measures on adults (N = 165, mean age = 45 +-12 SD) from physiotherapy clinics in *(xxx), (xxx), and (xxx, 3 countries).* Inclusion: NSCLBP > 6 months, aged 18-64, predominant CS pain presentation, no other pathology. Parametric and non-parametric correlation statistics and regression analyses were used.

Results: Positive correlations were found between central sensitisation inventory (CSI) scores and sensory hyper-sensitivity profiles and trait anxiety. CSI score increases could be predicted by: Sensory Sensitive, Low Registration profiles, trait anxiety scores and extreme defensive high anxious personality type.

Conclusions: Trait sensory hyper- and/or hypo-sensitivity and high trait-anxiety related personality type characteristics predicts the extent of CS symptoms in people with NSCLBP.

Further investigation is required to establish causality between these characteristics and CS symptoms.

Abstract word count - 244

Key Words:

Central sensitisation; Non-specific chronic low back pain; Predicting central sensitisation symptom scores; Trait characteristics; Sensory profiles; Trait anxiety; Personality type; Cross-sectional observational study.

Introduction

Central Sensitisation (CS) as a predominant pain mechanism is found in many musculoskeletal pain conditions [1-3]. Central sensitisation is defined as a dysregulation of the central nervous system causing neuronal hyper-excitability, characterized by generalized hypersensitivity of the somatosensory system to both noxious and non-noxious stimuli [4-6]. A musculoskeletal pain population commonly subject to CS symptoms is that with non-specific chronic low back pain (NSCLBP) [1, 7]. NSCLBP has significant impact on both the society [8] and the individual.

To date there is limited evidence to identify the factors and mechanisms that contribute towards the development of CS in musculoskeletal pain. It is proposed that individuals with high trait sensitivity prior to the onset of low back pain may be more prone to CS, based on the heightened sensory sensitivity experienced in CS pain. People with CS symptoms [4, 9], high trait anxious individuals [10, 11],[12] and people with high trait sensory sensitivity [11, 13] all experience a heightened sensitivity to sensory stimuli in the form of physiological arousal. Physiological arousal is a response to stressors which acts as a pre-cursor to a behavioural response and may contribute to heightened sensitivity to pain and the experience of CS symptoms.

Trait sensitivity to sensory stimuli

Twenty to thirty percent of individuals in healthy populations have been found to be naturally highly sensitive to environmental and bodily sensory stimuli [14-16]. Furthermore, healthy populations have been described as being on a spectrum of sensitivity from low to high [1, 13]. Trait anxiety may be an indirect measure of trait sensory sensitivity, based on physiological arousal responses to sensory stimuli among individuals with high trait anxiety

personality types [17]. Physiological arousal occurs as a precursor to interpretation and action responses[18].

Trait sensitivity has been measured in various populations using the Adolescent Adult Sensory Profile (AASP) [13, 19-22]and, more recently, in a NSCLBP population with CS pain [23 24]. The AASP identifies neurological thresholds and behavioural responses to various sensory stimuli including taste and smell, visual, auditory, touch, and activity[25].

Behavioural responses to sensory stimuli

Sensory stimulation can be excessive in people with low neurological thresholds, or insufficient in people with high neurological thresholds , and the resulting discomfort may be modulated by an adaptive behavioural response [13]. The behavioural responses described by Brown et al. (2001) can be active to restore comfort, or passive in which discomfort continues [25]. Furthermore, an individual's personality type can determine behavioural responses to stressors and physiological arousal, through their interpretation and action[16.]

Weinberger et al. (1979) proposed four personality types that will respond to stressors differently [26]. These four personality types are determined by levels of trait anxiety and defensiveness: High anxious (high anxiety, low defensiveness), defensive high anxious (high anxiety, high defensiveness), low anxious (low anxiety, low defensiveness), and repressor (low anxiety, high defensiveness). It was proposed that these individuals possess cognitive biases which could influence their perception of, and response to, physiological arousal, according to Eysenck's Four Factor Theory[17]. Eysenck's four factor theory [17] underpins some of the interpretation framework included within the current study and was designed to be applied to Weinberger's four personality types.

Eysenck's four factor theory is based on the assumption that there are consistent cognitive biases which operate via four different factors within the emotional system. These cognitive biases are the attentional and interpretational biases and they differ between each of the four personality types [17]. The four factors of the emotional system which influence the individual's experience of state anxiety, in response to perceived threats, are:

(i) the cognitive appraisal of the 'stressful' situation;

(ii) the individual's attention to and interpretation of the concurrent physiological arousal;

(iii) the individual's action tendencies;

(iv) the negative thoughts and emotions in relation to the uncertainty of the outcome (e.g. worries).[17]

Eysenck [17] stated that defensive high anxious and high anxious individuals would show attentional bias towards sensory stimuli and interpretational bias for threat. Conversely the theory states that repressors are more likely to interpret against threat and show avoidant bias towards sensory stimuli. These assertions were supported by Franklin et al. when applied to people with NSCLBP. [27, 28]

It is proposed that trait sensory sensitivity profiles and trait anxiety may contribute to a proneness to respond to stressors with physiological arousal. Subsequently, behavioural responses, determined by individual personality types, may contribute towards the development of CS symptoms by further heightening sensitivity to stimuli perceived as threatening. If stimuli are interpreted as threatening, they can become nociceptive whereby pain is experienced [29].

The current study hypothesises that in a NSCLBP population with predominant CS pain, individual characteristics involving high trait sensitivity, (sensitivity profiles and trait anxiety) and responses which serve to further heighten sensitivity (personality types) may be identified and that these will be significantly associated with the extent of CS symptoms.

The objectives of this study were to investigate 1) the relationships between the four trait sensory profiles, the extent of CS symptoms and trait anxiety, and 2) the ability of the trait sensory profiles, trait anxiety scores and personality types to predict the extent of CS symptoms, across a group of people with predominantly CS pain in a NSCLBP population.

Methods

This study is presented according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [30].

Design

An international cross sectional observational study design [31] across a group of people with NSCLBP and CS was used in 3 countries and 2 continents. Ethical approval (ref:1205) was given by [xxx] the Research and Development departments of the participating hospitals (IRAS REC no.:15/NW/0378) in [xxx] and permission was obtained from the Northern Y Ethics Committee, [xxx].

Sample

The required sample size was calculated based on a mean sample size calculated from three suggested methods: 1) For a regression analysis, with a power of 80% and alpha (α) set at 0.05, a value of $R^2 \geq 0.23$ can be detected with n = 50 participants [32], where n = 50 must make up the smallest variable, which was anticipated to be around 26% [27] (n = 192); 2) a minimum of 15 to 20 participants per variable is recommended for regression analyses [32] and 10 to 15 participants per variable for correlation analysis [33] with 9 variables, (n = 180). For multiple correlation n > 50 + *m*8, where *m* is the number of variables, for a moderate effect size [32] (minimum n = 122). Using these 3 suggested sample sizes, a mean sample size was derived: n = 165.

Recruitment

Recruitment took place between July 2015 and March 2017 in 8 physiotherapy and pain clinics in N(xxx) (n = 82), 3 in E(xxx) (n = 36) and 2 in I(xxx) (n = 47). A total of 165 participants, aged 18 to 64 years (mean 45, +/-12 SD) were recruited, 126 of whom were female. People from clinical populations with non-specific chronic low back pain (NSCLBP) were recruited by. Recruitment was undertaken by senior physiotherapists experienced in pain neurophysiology and management, who could determine whether each participant met the strict clinical inclusion criteria for NSCLBP and a predominant CS pain presentation. [34], (Table 1).

Table 1.

All participants satisfying the inclusion criteria were given a participant information sheet by their health care provider. Consent was obtained at their subsequent visit to the clinic by the same health care provider. Participants were asked to complete the study

questionnaires with the option of completing them at home or at the clinic. No monetary compensation was offered to them and no incentives were made, to avoid coercion. It was made clear to all potential participants that any subsequent health care they may receive would not be affected. For ambiguously answered or omitted questions, participants were contacted where possible by a third-party administrator by telephone, thereby reducing the risk of any primary-researcher influence, to clarify responses.

Outcome Measures

Central Sensitisation Inventory (CSI)

The CSI [5 6] measures the extent to which an individual's symptoms are likely to be attributable to CS. Part A of this two-part questionnaire has 25 symptom related items. These items are scored on a Likert scale (0-4, score range 0-100, where 100 is maximum central sensitisation symptoms). The CSI has been shown to be valid and reliable [5] with a test-retest reliability of 0.82 and Cronbach's alpha of 0.88, sensitivity of 81% and specificity of 75% [6]. CSI scores are classified into symptom severity levels of clinical relevance, such that 0-20 is sub-clinical, 21-40 is mild, 41-50 is moderate, 51-60 is severe and 61-100 is extreme [35]. Part B lists 10 central sensitivity syndromes and asks if any have been diagnosed by a doctor (yes / no; score range 0-10).

Adolescent / Adult Sensory Profile questionnaire (AASP)

The AASP [25] is a 60 item questionnaire which identifies trait sensory sensitivity profiles which are based on Dunn's original model of sensory processing [36]. The AASP combines the neurological thresholds to sensory stimuli with adaptive behavioural response continua to

sensory stimulation. A summary score is calculated for each sensory profile as follows: Sensory Sensitive (low neurological threshold, passive adaptive response), Sensation Avoidance (low threshold, active response), Low Registration (high neurological threshold, passive adaptive response) and Sensation Seeking (high threshold, active response), summarised in Table 2. Items are scored 1-5 using a Likert scale based on frequency of sensory-related experiences from "almost never" to "almost always" respectively. Scores in each profile range from: 'much less than-', 'less than-', 'similar to-', 'more than-' and 'much more than- most people'. Normal values and standard deviation values have been established in a healthy population (n = 495 [25]). Acceptable reliability was found for each sensory profile with coefficient alphas of: Sensory Sensitive = 0.81; Sensation Avoiding = 0.66; Low Registration = 0.82 and Sensation Seeking = 0.79 [25]. The coefficient alpha in a larger group of 615 healthy adults ranged from 0.66-0.82. Factor analysis for all four sensory profiles is supportive of Dunn's original sensory profile model [36].

Table 2:

The current study obtained cross-sectional data, for which the AASP questionnaire has previously been validated [25]. The populations for which the AASP has been validated include people with sensory processing differences such as autism spectrum disorder and specific learning difficulties. Two concurrent longitudinal validation studies to validate the use of the AASP in musculoskeletal pain populations with predominantly CS pain are being undertaken, in the Dutch and English languages. Preliminary results on the Dutch version of the AASP in people with musculoskeletal pain with CS show good internal consistency (Cronbach's alpha 0.91) and individually the Cronbach's alpha for the four sensory profiles: Low Registration 0.91; Sensation Seeking 0.90; Sensory Sensitive 0.92 and for Sensation Avoiding 0.92.

Furthermore, the test-retest reliability was considered excellent for all four sensory profiles with the intra-class correlation coefficients as: Low Registration 0.83, 95% CI 0.73 to 0.89; Sensation Seeking 0.82, 95% CI 0.72 to 0.89; Sensory Sensitive 0.85, 95% CI 0.77 to 0.91 and Sensation Avoiding 0.84, 95% CI 0.75 to 0.90 [37].

State-Trait Anxiety Inventory (STAI)

The STAI (Trait section; [12]) measures a person's trait anxiety. Trait anxiety is an enduring, relatively stable character trait and is an indicator of the likelihood of the person responding to perceived threats with (transient) state anxiety. Trait anxiety is associated with sensitivity to sensory stimuli [11]. The STAI (trait section) is a 20-item questionnaire, scored 0-80 (where 80 is maximum trait anxiety) using a 1- to 4-point Likert scale with answers ranging from 'not at all' to 'very much so'. Internal consistency coefficients range from 0.86 to 0.95 and test-retest reliability coefficients range from 0.65 to 0.75 over a 2-month interval [12].

Marlowe Crowne Social Desirability Scale (MCSDS)

The MCSDS [38] measures defensiveness / social desirability and may be used in conjunction with the STAI-T to identify a personality type [26]. The Short Form version [39] of the MCSDS was used. It is a 10-item questionnaire answered by "true" or "false" responses and scored from 0-10. An internal consistency alpha coefficient has been reported as 0.66 and a correlation coefficient of $r = 0.90$ ($p < 0.001$) [40] between the 10 item MCSDS and the original 33 item MCSDS [38]. The short form version was therefore chosen for its time-logistic advantage.

The four personality types were identified using mean STAI and MCSDS scores from normative data, similar to the use of normative data for cut-off scores by other authors [41]. The method of identification of the four personality types using scores above (high) and below (low) a cut-off score on the trait anxiety and defensiveness measures has been used previously [42, 43]. For the current study the STAI mean and standard deviations were calculated from four different healthy population studies [12, 44]: STAI mean = 39, (SD = 10)., whereby < 39 = low anxious and ≥ 39 = high anxious. MCSDS normative data was drawn from a previous healthy population study [45] which found a MCSDS mean of 5.4 (mode = 5), whereby ≤ 5 = low defensiveness and > 5 = high defensiveness. In line with the method used to identify extreme scores in the AASP, that is - scores above or below one standard deviation (SD) from the mean normative scores from healthy populations, sub-groups of extreme personality types were also identified for comparison. The identification and sub-grouping of personality types are summarised in table 3.

Table 3:

Data Management

After the completion of the questionnaires had been checked, the questionnaires were pseudo-anonymised by removing the front page with identifiable information on it. The questionnaires were each allocated a research number for identification and the front sheets filed separately with the corresponding number noted on them. Any missing data items (< 1%) were entered using the individual participant's mean score of the measure in question.

Analysis

All data were analysed using IBM SPSS Statistics version 22 [46]. Descriptive statistics were used to describe the demographics of the group. Tests for normality were undertaken for each variable scale, using the Shapiro Wilks test. Normally distributed variables were analysed using Pearson's correlation statistics and non-normally distributed variables were analysed using Spearman's Rho correlation statistics. These preliminary tests are detailed in table 4. The primary outcome was the CSI measure.

Table 4:

Results were adjusted with the removal of the repressor personality types for comparison. A hierarchical logistic regression model was used to calculate the capacity in which the trait sensory profile scores and trait anxiety scores might predict CSI scores (indicated by the beta (β) values). The most likely predictors were identified from the correlation analyses.

After checking for multicollinearity, using a multiple correlation analysis between the identified variables where r must not be more than 0.9 [33], a step-forward analysis was used to find out the individual contribution of each predictor. Using the hierarchical method, the CSI as the dependent variable was entered at the first stage with the Sensory Sensitive profile scores, followed by the Low Registration profiles and STAI scores in the second stage, as the independent variables. R values represent the multiple correlation coefficient between predictors and outcome and R^2 values represent the variability accounted for in the outcome by the predictors.

The second regression analysis using block entry [33] included the dependent variable CSI score and independent variables personality type. Each personality type, determined by two

combined scale measures, were transformed into categorical data using dummy variables [33]. The low anxious variable was assigned as the baseline group and compared with the more prevalent personality types. 95% confidence intervals were calculated using bootstrapping method (N=1000).

Results

Demographics

The study group consisted of people with extreme scores (+/- 1 SD) of one or more of the following sensory profiles: 1) high trait Sensory Sensitivity (n = 91; 55%), Sensation Avoidance (n = 72; 44%) and Low Registration (n = 60; 36%), and 2) low trait Sensation Seeking (n = 62; 38%) sensory profiles. The proportions of personality types across the whole study group were: Defensive high anxious, n = 75, 45%, (extreme sub-group n = 19; 12%), high anxious n = 43, 26% (extreme sub-group n = 23; 14%) and repressor n = 41, 25% (extreme sub-group n = 8; 5%). Part B of the CSI showed a median score of 2 concurrent sensory sensitivity diagnoses (mean 2.25, SD 1.8). N = 24 had a concurrent diagnosis of fibromyalgia. 32% of the sample were not taking any pain medication and there was no significant difference in CSI scores between those individuals and those who were taking pain medication. Twelve people (6.8%, n = 5 male) refused to participate, n = 6 from I(xxx), n = 1 from E(xxx) and n = 5 from N(xxx).

Associations between Trait Sensory Sensitivity, Trait Anxiety and the Central Sensitisation Inventory Scores

Associations were observed between the sensory profile scores (AASP) and 1) the CSI scores and 2) the STAI scores. Further associations were observed between the CSI and the STAI scores

Relationships between Trait Sensory Profile and Central Sensitisation Inventory Scores

Moderate positive correlations were found between the CSI and the Sensory Sensitivity (r = 0.63, CI = 0.53 – 0.59), Sensation Avoiding (r = 0.48, CI = 0.40 – 0.59) and Low Registration (r = 0.54, CI = 0.42 – 0.64) profiles. A weak negative correlation was found between the CSI and the Sensation Seeking profile (r = -0.23, CI = -0.81 to -0.35). $P < 0.01$.

Relationships between the Trait Sensory Profiles and Trait Anxiety Scores

A moderate positive correlation was found between trait anxiety scores and Sensory Sensitive (r = 0.43, CI = 0.28 – 0.56), a weak positive correlation between Sensation Avoiding r = 0.33, CI = 0.17 – 0.47) and Low Registration (r = 0.27, CI = 0.11 – 0.42) profiles, and a weak negative correlation between Sensation Seeking (r = -0.21, CI = -0.07 to -0.35). $P < 0.01$.

Relationships between Trait Anxiety and the Central Sensitisation Inventory Scores

There was a moderate positive correlation between trait anxiety and CSI scores (r = 0.46, CI = 0.31 – 0.60). Repressors tend to under report their anxiety on the STAI [43] and this has been recognised as a potential problem in previous research where self-report measures are

utilised [17]. It was considered possible, therefore, that a stronger correlation might be found between STAI and CSI scores if the repressor group was excluded. A secondary analysis was performed in which the correlation was recalculated after exclusion of the repressor personality type group, resulting in a similar relationship between STAI and CSI (r = 0.437, CI = 0.27 – 0.58; p = 0.01).

Regression analysis

Trait anxiety

The first regression analysis tested whether CSI scores could be predicted by trait sensory profile scores, and/or trait anxiety scores. The predictors of CSI scores, identified from the correlation analyses, were most likely to be the Sensory Sensitive and Low Registration sensory profile scores and the STAI scores.

Tests for multicollinearity between the CSI and Sensory Sensitive scores, Low Registration scores and STAI scores showed minimal multicollinearity between the predictors ($p < 0.001$); Table 5. The model summary showed R = 0.628 for step 1 and R = 0.712 for step 2. R^2 = 0.394 whereby the Sensory Sensitive profile score accounts for 39.4% of variability in the CSI scores. R^2 = 0.498 for step 2 whereby, in conjunction with the STAI and Low Registration scores, the Sensory Sensitive score accounts for 50.7% variability in the CSI scores. Adjusted R^2 scores were comparable to R^2 with 0.003% and 0.009% difference for steps 1 and 2 respectively, showing cross validity to be good ($P<0.001$). The Durbin Watson score to check the assumption of independent errors was acceptable at 1.834.

Table 5:

Table 6 shows unstandardized (B and standard error) and standardised (Beta) coefficients of the regression model, including the SD for each variable.

Table 6:

Personality type

The second regression analysis was to investigate whether CSI scores could be predicted by personality type. No relationships were found between the whole-group (inclusive of the extreme sub-group) personality types and CSI scores. Therefore, extreme personality type sub-groups were isolated, and the analysis repeated. Extreme sub-groups of personality types were entered by block entry into the model. The Durbin Watson score to check the assumption of independent errors was acceptable at 2.12. Extreme personality types accounted for 14% of variance in CSI scores, which according to the ANOVA, was significant ($p = 0.048$). The extreme defensive high anxious personality type contributed to increases in CSI scores the most ($P=0.05$), whereas the high anxious and repressor personalities did not (Table 7).

Table 7:

Discussion

This is the first study to identify inter-relationships between the extent of CS symptoms and 1) trait sensory hyper- and hypo-sensitivity; 2) trait anxiety and 3) personality type, in people with NSCLBP. This is also the first study to demonstrate the capacity of trait sensory hyper- and hypo-sensitivity, trait anxiety and the defensive high anxious personality type to predict the extent of CS symptoms in people with NSCLBP.

Interpretation of the correlation analyses shows that the greater the extent of symptoms of CS in people with NSCLBP, a) the higher the extent of trait sensory hyper-sensitivity: (Sensory Sensitivity and Sensation Avoiding) and b) trait sensory hypo-sensitivity: Low Registration with a passive adaptive response to sensory under-stimulation. Also, the greater the extent of CS symptoms the lesser the tendency to respond to sensory under-stimulation with an active compensatory response (Sensation Seeking profile).

In addition, the results of the correlation statistics show that in the current study the more trait anxious the participants were, the more they showed trait sensory hyper-sensitivity (Sensory Sensitive and Sensation Avoiding respectively) and less so, trait sensory hypo-sensitivity with passive adaptive responses (Low Registration). This is similar to another study [47] in which trait anxiety was found to correlate positively with the Sensory Sensitive, Sensation Avoiding and Low Registration profile scores in healthy adult populations.

The Sensory Sensitive, Sensation Avoiding and Low Registration profiles have been positively correlated with pain catastrophising (using the pain catastrophising scale) in another study, although the correlations were weak, possibly due to the respondents being healthy [48]. The correlation found between trait anxiety and the Sensation Avoiding profile (low neurological threshold, active adaptive response) in people with NSCLBP may link with fear avoidance as a response to symptoms. The Sensation Avoiding profile has been found to be predictive of state anxiety in healthy adults [47] suggestive of a possible tendency to reactive responses to pain. However, because Sensation Avoiding is a trait characteristic it is less likely to be a reactive behaviour to symptoms in people with NSCLBP, but behavioural responses learned from pre-morbid years. The findings of a concurrent nested qualitative study showed that emotional and physical sensory sensitivities had been present in the lives of the participants

with NSCLBP pre-morbidly [49]. The qualitative findings provide support for the assertion that these were trait characteristics that had been present prior to the onset of low back pain and CS, and not limited to reactive responses to symptoms, in people with NSCLBP.

Regression analysis in the current study found trait anxiety to be a predictor of CSI scores in people with NSCLBP, reflective of the tendency of high trait anxious individuals to react to threats with state anxiety. State anxiety is a stress response and chronic stress has been identified in animal work as an activator of glial cells in the central nervous system which may be associated with neuroinflammation and subsequent CS onset or aggravation [50]. It is suggested that discomfort experienced by sensory under- or over-stimulation [13, 51] constitute as stressors, which leads to a stress response[13, 47]. Physiological changes, occur in the central nervous system (CNS) in response to stressors, including those associated with autonomic arousal. Physical and emotional stressors may be perceived or may remain unconscious and threaten the homeostatic and/or emotional wellbeing of the individual [18, 52]. Trait anxiety and trait sensory sensitivity are related to a proneness to physiological arousal to stressors [14, 15, 17, 53, 54]. Stress responses involve the autonomic nervous system and the hypothalamic-pituitary-adrenal (HPA) axis in which cortisol is released as part of the anti-inflammatory response, [52, 55, 56]. Chronic reactivation of the stress response with repeated releases of cortisol may result in cortisol dysfunction [55]. Cortisol dysfunction and a dysfunctional HPA axis have been found in conditions linked to CS such as chronic low back pain and fibromyalgia [57, 58].

The current study showed a prevalence of 12% in the extreme sub-group of defensive high anxious participants, and whilst dominant, was on the verge of significance (p=0.05). This is similar to 13% found among a group of target shooters and hockey players with low back

pain [28], and less than a group of people with chronic low back pain where CS was not specified (26%), [27]. The difference between the prevalence of defensive high anxious participants in the current and the latter [27] studies may have been due to the latter having a much lower cut-off score (STAI ≥ 42, as opposed to STAI ≥ 49 in the current study) for identification of extreme defensive high anxious individuals, making the prevalence greater.

Extreme defensive high anxious individuals tend to respond to the physiological arousal associated with stressors with vigilance towards the stimuli, interpretation of the stimuli as threatening [17, 27, 28] and persistence in their seeking of multiple medical interventions for their chronic low back pain significantly more so than the other three personality types [28]. This may explain why the factor of extreme defensive high anxious personality type contributes, in part, to the prediction of symptoms of CS.

Repressors show a bias by rapidly attending to threat-related stimuli (vigilance) and then actively avoid negative affect by shifting their attention away from the stimuli (avoidance) [59]. Repressors may be vigilant towards somatic symptoms of CS but rapidly shift their attention away and avoid them [43]. Associations between the Sensation Avoiding profile and the repressor personality type, in people with NSCLBP requires further investigation.

Both the sensory profiles with the passive behavioural response to over- or under-stimulation predict the extent of CS symptoms (Sensory Sensitive and Low Registration) in people with NSCLBP. Self-efficacy has been found to be low in chronic back pain populations [60] which may link with passive adaptive behaviours seen in the current study. Sensory hypo-sensitivity (Low Registration) was an unexpected predictor of CS symptoms insomuch as CS is characterised by sensory hyper-sensitivity. The current study did not allow for identification of which specific senses were hypo-sensitive and this warrants further

investigation. It may be hypothesised that the discomfort experienced from a lack of sensory feedback, which remains uncompensated for in a passive adaptive response, may be interpreted as threatening by high trait anxious individuals and this in turn may lead to a physiological arousal stress response.

The clinical implications for these trait characteristics are that if individuals present with NSCLBP and they are found to have high trait sensory hyper-sensitivity and / or a Low Registration profile, high trait anxiety or an extreme defensive high anxious personality type, their symptoms are likely to be related to CS rather than a predominant nociceptive pain mechanism. Management may require education about sensory requirements and responses to stressors and this warrants further investigation.

Results of the regression analysis provides ground-work for a longitudinal study to test for trait Sensory Sensitivity and Low Registration sensory profiles, trait anxiety and the extreme defensive high anxious personality type as predictors of CS symptoms from a pre-pain or acute pain baseline in people with NSCLBP. This would enable clinicians to identify patients at risk of CS symptoms and tailor management accordingly.

Strengths and limitations

Strengths included the rigorous methodology used and reported according to the STROBE guidelines [61]. Recruitment followed published clinical guidelines for identification of people with predominantly CS pain [34], thereby increasing homogeneity within the sample. Selection bias was limited, and external validity was facilitated by ensuring participants were recruited

by multiple participating health care providers, rather than just one principle investigator, and across three countries and two continents.

Limitations included information not being available from participating clinicians as to the specific demographics regarding the participants who refused to participate. Furthermore, no record was made as to which specific variables contained missing data although these were very few and were spread across the outcome measures. The study recruited more female than male participants, which may present as a limitation, or may be reflective of females with chronic pain tending to seek treatment more than males [62].

Conclusion

This is the first study to demonstrate that trait characteristics of trait sensory hyper-sensitivity and trait anxiety are positively associated with the extent of CS symptoms, and that Sensory Sensitivity and Low Registration sensory profile scores, trait anxiety scores and the defensive high anxious personality type have some capacity to predict the extent of CS symptoms in people with NSCLBP. Further studies to investigate relationships between 1) sensory profiles and personality types and 2) specifically the Sensation Avoidance sensory profile and the Repressor personality type in people with NSCLBP would be of value to better understand sensory hypo-sensitivity in CS. Longitudinal predictive studies from a pre-morbid or acute pain stage baseline to test trait characteristics of the Sensory Sensitive and Low Registration sensory profiles and trait anxiety as predictors of CS symptoms in people with NSCLBP are recommended. If predictive factors in the development of CS symptoms can be identified, “at risk” people can be targeted at baseline with appropriate management to reduce the risk of CS, which in turn may reduce the burden of NSCLBP on society.

No conflicts of interest to declare.

References

1. Clauw, D.J., *Diagnosing and treating chronic musculoskeletal pain based on the underlying mechanism(s).* Best Practice & Research Clinical Rheumatology, 2015.
2. Yunus, M.B., *Central Sensitivity Syndromes: A New Paradigm and Group Nosology for Fibromyalgia and Overlapping Conditions, and the Related Issue of Disease versus Illness.* Seminars in Arthritis and Rheumatism, 2008. **37**(6): p. 339-352.
3. Arendt-Nielsen, L., et al., *Assessment and manifestation of central sensitisation across different chronic pain conditions.* Eur J Pain, 2018. **22**(2): p. 216-241.
4. Nijs, J., B. Van Houdenhove, and R.A.B. Oostendorp, *Recognition of central sensitization in patients with musculoskeletal pain: Application of pain neurophysiology in manual therapy practice.* Manual Therapy, 2010. **15**(2): p. 135-141.
5. Mayer, T.G., et al., *The Development and Psychometric Validation of the Central Sensitization Inventory.* Pain Practice, 2012. **12**(4): p. 276-285.
6. Neblett, R., et al., *The central sensitization inventory (CSI): Establishing clinically significant values for identifying central sensitivity syndromes in an outpatient chronic pain sample.* Journal of Pain, 2013. **14**(5): p. 438-445.
7. Roussel, N.A., et al., *Central sensitization and altered central pain processing in chronic low back pain: fact or myth?* The Clinical Journal Of Pain, 2013. **29**(7): p. 625-638.
8. Apkarian, A.V., et al., *Corticostriatal functional connectivity predicts transition to chronic back pain.* Nature Neuroscience, 2012. **15**: p. 1117+.
9. Wolfe, F., et al., *The American College of Rheumatology Preliminary Diagnostic Criteria for Fibromyalgia and Measurement of Symptom Severity.* Arthritis Care & Research, 2010. **62**(5): p. 600-610.
10. Eysenck, M. and A. Byrne, *Anxiety and susceptibility to distraction.* Personality and Individual Differences, 1992. **13**(7): p. 793-798.
11. Ansari, T.L. and N. Derakshan, *The neural correlates of impaired inhibitory control in anxiety.* Neuropsychologia, 2011. **49**(5): p. 1146-1153.

12. Spielberger, C.D., *Manual for the State-Trait Anxiety Inventory STAI (form Y)(" self-evaluation questionnaire").* 1983.
13. Brown, C., et al., *The Adult Sensory Profile: Measuring Patterns of Sensory Processing.* American Journal of Occupational Therapy, 2001. **55**(1): p. 75-82.
14. Lionetti, F., et al., *Dandelions, tulips and orchids: evidence for the existence of low-sensitive, medium-sensitive and high-sensitive individuals.* Translational Psychiatry, 2018. **8**(1): p. 24.
15. Acevedo, B., et al., *The functional highly sensitive brain: a review of the brain circuits underlying sensory processing sensitivity and seemingly related disorders.* Philosophical Transactions of the Royal Society B: Biological Sciences, 2018. **373**(1744): p. 20170161.
16. Pluess, M., *Individual Differences in Environmental Sensitivity.* Child Development Perspectives, 2015. **9**(3): p. 138-143.
17. Eysenck, *Anxiety and Cognition. A Unified Theory.* 1997, Hove

UK: Psychology Press. 200.
18. Schouten, M., et al., *microRNAs and the regulation of neuronal plasticity under stress conditions.* Neuroscience, 2013. **241**: p. 188-205.
19. Brown, C., et al., *Sensory processing in schizophrenia: Missing and avoiding information.* Schizophrenia Research, 2002. **55**(1): p. 187-195.
20. Engel-Yeger, B. and W. Dunn, *Exploring the Relationship between Affect and Sensory Processing Patterns in Adults.* The British Journal of Occupational Therapy, 2011. **74**(10): p. 456-464.
21. Engel-Yeger, B., R. Hardal-Nasser, and E. Gal, *Sensory processing dysfunctions as expressed among children with different severities of intellectual developmental disabilities.* Research in Developmental Disabilities, 2011. **32**(5): p. 1770-1775.
22. Engel-Yeger, B., et al., *Sensory processing patterns of adults with atopic dermatitis.* Journal of the European Academy of Dermatology and Venereology, 2011. **25**(2): p. 152-156.
23. Clark, J.R., G. Yeowell, and P.C. Goodwin, *Trait anxiety and sensory processing profile characteristics in patients with non-specific chronic low back pain and central sensitisation - A pilot observational study.* Journal of Bodywork and Movement Therapies, 2018. **22**(4): p. 909-916.
24. Clark, J., et al., *Prevalence of extreme trait sensory profiles and personality types in non-specific chronic low back pain and predominant central sensitisation. Secondary analysis of an international observational study.* Clinical Journal of Pain.
25. Brown, C. and W. Dunn, *Adolescent-adult sensory profile: user's manual*. 2002: Therapy Skill Builders Tucson, AZ.
26. Weinberger, D.A., G.E. Schwartz, and R.J. Davidson, *Low-anxious, high-anxious, and repressive coping styles: Psychometric patterns and behavioral and physiological responses to stress.* Journal of Abnormal Psychology, 1979. **88**(4): p. 369-380.

27. Franklin, Z., et al., *Personality Type Influences Attentional Bias in Individuals with Chronic Back Pain.* PloS one, 2016. **11**(1): p. e0147035.
28. Franklin, Z., N. Smith, and N. Fowler, *Defensive high-anxious individuals with chronic back pain demonstrate different treatment choices and patient persistence.* Personality and Individual Differences, 2014. **64**(0): p. 84-88.
29. Moseley, G.L. and D.S. Butler, *Fifteen Years of Explaining Pain: The Past, Present, and Future.* The Journal of Pain, 2015. **16**(9): p. 807-813.
30. Von Elm, E., et al., *The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies.* PLoS medicine, 2007. **4**(10): p. e296.
31. Robson and Colin, *Real World Research*

A Resource for Social Scientists and Practitioner Researchers Vol. 2nd Edition. 2002, Malden, USA

Oxford, UK

Victoria, Australia Blackwell Publishing. 544.
32. Thabane, L. *Sample Size Determination in Clinical Trials*. McMaster University HRM-733 Class Notes, 2004. **1**, 1-42.
33. Field, A., *Discovering Statistics using SPSS. Third Edition.* 3rd ed. 2009, Sage Publications Ltd.

1, Oliver's Yard,

55, City Rd.,

London Sage Publications Ltd. 1-816.
34. Smart, K.M., et al., *Mechanisms-based classifications of musculoskeletal pain: Part 1 of 3: Symptoms and signs of central sensitisation in patients with low back (±leg) pain.* Manual Therapy, 2012. **17**(4): p. 336-344.
35. Neblett, R., et al., *Establishing clinically relevant severity levels for the central sensitization inventory.* Pain Practice, 2017. **17**(2): p. 166-175.
36. Dunn, W., *The Impact of Sensory Processing Abilities on the Daily Lives of Young Children and Their Families: A Conceptual Model.* Infants & Young Children, 1997. **9**(4).
37. Graeper P, Clark J, Lennox-Thompson B, Hallegraeff JM, Measuring sensory profiles in a nonspecific chronic low back pain population: an observational study. *Physiotherapy Theory and Practice* (submitted)
38. Crowne, D.P. and D. Marlowe, *A new scale of social desirability independent of psychopathology.* Journal of consulting psychology, 1960. **24**(4): p. 349.
39. Strahan, R., *Short, homogeneous versions of the Marlow-Crowne Social Desirability Scale.* Journal of clinical psychology, 1972. **28**(2): p. 191-193.
40. Reynolds, W.M., *Development of reliable and valid short forms of the marlowe-crowne social desirability scale.* Journal of Clinical Psychology, 1982. **38**(1): p. 119-125.

41. Lewis, S.E., et al., *Defensive coping styles, anxiety and chronic low back pain.* Physiotherapy, 2012. **98**(1): p. 86-88.
42. Jensen, M.R., *Psychobiological factors predicting the course of breast cancer.* Journal of personality, 1987. **55**(2): p. 317-342.
43. Myers, L.B., *The importance of the repressive coping style: findings from 30 years of research.* Anxiety, stress, and coping, 2010. **23**(1): p. 3-17.
44. Kendall, P.C. and R.C. Sheldrick, *Normative data for normative comparisons.* Journal of Consulting and Clinical Psychology, 2000. **68**(5): p. 767-773.
45. Johnson and Fendrich, *A validation of the Crowne- Marlowe So cial Desirability Scale. Paper presented at the 57th Annual Conference of the American Association for Public Opinion Research, St Petersburgh, Florida, USA. 16th-19th May 2002. Available at*

http://www.srl.uic.edu/publist/Conference/crownemarlowe.pdf 2002.
46. Corp., I., *IBM SPSS Statistics for Windows*. 2013, IBM Corp.: Armonk, NY.
47. Engel-Yeger, B. and W. Dunn, *The Relationship between Sensory Processing Difficulties and Anxiety Level of Healthy Adults.* The British Journal of Occupational Therapy, 2011. **74**(5): p. 210-216.
48. Engel-Yeger, B. and W. Dunn, *Relationship Between Pain Catastrophizing Level and Sensory Processing Patterns in Typical Adults.* The American Journal of Occupational Therapy, 2011. **65**(1): p. e1-e10.
49. Clark, J., P. Goodwin, and G. Yeowell, *Exploring pre-morbid experiences and personal characteristics in centrally sensitised people with non-specific chronic low back pain: A qualitative study.* The Brazilian Journal of Physiotherapy.
50. Nijs, J., et al., *Sleep disturbances and severe stress as glial activators: key targets for treating central sensitization in chronic pain patients?* Expert Opinion on Therapeutic Targets, 2017. **21**(8): p. 817-826.
51. Dunn, W. and C. Brown, *Factor Analysis on the Sensory Profile From a National Sample of Children Without Disabilities.* American Journal of Occupational Therapy, 1997. **51**(7): p. 490-495.
52. Woda, A., P. Picard, and F. Dutheil, *Dysfunctional stress responses in chronic pain.* Psychoneuroendocrinology, 2016. **71**: p. 127-135.
53. Eysenck, et al., *Anxiety and cognitive performance: Attentional control theory.* Emotion, 2007. **7**(2): p. 336-353.
54. Walsh, J.J., et al., *Interpretive bias, repressive coping, and trait anxiety.* Anxiety, Stress, & Coping, 2015. **28**(6): p. 617-633.
55. Hannibal, K.E. and M.D. Bishop, *Chronic Stress, Cortisol Dysfunction, and Pain: A Psychoneuroendocrine Rationale for Stress Management in Pain Rehabilitation.* Physical Therapy, 2014. **94**(12): p. 1816-1825.
56. Koolhaas, J.M., et al., *Stress revisited: A critical evaluation of the stress concept.* Neuroscience & Biobehavioral Reviews, 2011. **35**(5): p. 1291-1301.
57. Tak, L.M. and J.G.M. Rosmalen, *Dysfunction of stress responsive systems as a risk factor for functional somatic syndromes.* Journal of Psychosomatic Research, 2010. **68**(5): p. 461-468.

58. Griep, E.N., et al., *Function of the hypothalamic-pituitary-adrenal axis in patients with fibromyalgia and low back pain.* J Rheumatol, 1998. **25**(7): p. 1374-81.
59. Derakshan, N., M. Eysenck, and L. Myers, *Emotional information processing in repressors: The vigilance–avoidance theory.* Cognition and Emotion, 2007. **21**(8): p. 1585-1614.
60. Woby, S.R., M. Urmston, and P.J. Watson, *Self-efficacy mediates the relation between pain-related fear and outcome in chronic low back pain patients.* European Journal of Pain, 2007. **11**(7): p. 711-718.
61. Vandenbroucke, J.P., et al., *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): Explanation and Elaboration.* PLOS Medicine, 2007. **4**(10): p. e297.
62. Cornally, N. and G. McCarthy, *Help-seeking behaviour for the treatment of chronic pain.* British journal of community nursing, 2011. **16**(2).