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Prevalence of Extreme Trait Sensory Profiles and Personality types in Non-specific Chronic Low Back Pain with Predominant Central Sensitisation: Secondary analysis of an international observational study.

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Abstract - **Background:** Individuals with non-specific chronic low back pain (NSCLBP) and central sensitisation (CS) exhibit sensory hypersensitivity which may be related to pre-existing trait characteristics. Sensory profiles and trait anxiety-related characteristics have sensory sensitivity in common with CS. **Objectives:** The objectives of this study were to observe 1) the prevalence of four personality types and extreme scores of four trait sensory profiles in people with NSCLBP and predominant CS; and 2) to compare these between two sub-groups based on high and low self-report CS symptoms. **Study Design:** An international cross-sectional observational study was undertaken. **Setting:** Adults (n=165; mean age = 45$\pm$12 SD) were recruited from physiotherapy clinics across 3 countries and 2 continents.

Methods: The inclusion criteria were: NSCLBP, aged 18 to 64, with clinically identified predominant CS pain, without specific pathology. The outcome measures were: Central sensitisation inventory (CSI), Adolescent/Adult Sensory Profile, State/Trait Anxiety Inventory and Marlowe Crowne Sociable Desirability Scale; Descriptive and comparative statistics were used. **Results**: CSI scores ranged from 19 – 79 (mean = 50). There was a high prevalence of extreme 1) trait sensory hyper- and, unexpectedly, hypo-sensitivity profile scores ($p<0.001$) and defensive high anxious personality type ($p<0.01$) in the high CSI (CSI ≥40; 78%) sub-group and 2) trait sensory hypo-sensitivity profile scores ($p<0.01$) and repressor personality ($p<0.01$) in the low CSI sub-group (CSI <40; 22%). **Limitations:** Self-report measures only were used; limited demographics. **Conclusions:** These results are the first to demonstrate extreme trait sensory profiles and personality types in people with NSCLBP and predominant CS. A sub-group who report low levels of CS symptoms may have a hypo-sensitive sensory profile and repressor personality type. Further study is required to investigate the extent to which these trait characteristics may predict CS symptoms in people with NSCLBP.

Key words:

Central sensitisation; Non-specific chronic low back pain; prevalence of extreme trait characteristics; sensory profiles; trait anxiety-related personality types.

Introduction

Chronic musculoskeletal pain is often characterised by the pain mechanism of central sensitisation whereby pain is experienced by the individual even when there is no or minimal pathology present (1), due to hypersensitivity of the nervous system to stimuli (sensory hypersensitivity). Central sensitisation (CS) 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 (2), (3), (4). A population prone to CS is a sub-group of people with non-specific chronic low back pain (NSCLBP); (5,6), a condition having tremendous impact on society (7).

A recent systematic review (8) of predictors of CS in adults with musculoskeletal pain found evidence to suggest that the presence of sensory hyper-sensitivity (tested using quantitative sensory testing; QST) and somatisation (psychological distress manifesting as reports of physical symptoms) pre-morbidly, or at the acute stage of pain, predict the development of CS at outcome (three or more months after pain onset). Other than genetic testing (9), none of the predictor studies measured the participants' trait characteristics. Following the results of the systematic review, further investigation into the role of trait characteristics of sensitivity was warranted. The question is posited in this study as to what aspects of an individual's trait characteristics might predispose them to the development of CS pain. Such aspects may include physiological and behavioural characteristics of sensitivity to sensory

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stimuli, which, as trait characteristics, may have been attributable to the individual prior to the development of CS pain and therefore may play an important role in its aetiology.

Physiological trait characteristics of sensitivity may include a lower neurological threshold to sensory stimuli than most people (10), and/or a greater tendency toward physiological arousal in response to perceived threats, as part of characteristics related to high trait anxiety (11,12). Furthermore, behavioural characteristics may include active or passive adaptive responses to sensory stimulation or discomfort according to an individual's trait sensory profile (10,13); or attention to, or avoidance of, sensory feedback according to the nature of the individual's personality type (12).

Dunn's (1997) trait sensory profile was designed to assess individual sensory preferences across five senses (auditory, visual, movement, touch, taste/small) and activity levels, giving a profile to illustrate the neurological thresholds to sensory stimulation (on a high to low continuum) and behavioural response to sensory discomfort (on a passive to active response continuum) (10). Insufficient or excessive sensory stimuli require an adaptive behavioural response to maintain optimum sensory stimulation and feedback (10,14). In people with extreme trait sensory profiles, sensory processing may be compromised (14) and this may be related to the altered central processing observed in people with CS pain (15-17). Studies using Dunn's trait sensory profile model have investigated sensory sensitivity and behavioural responses in other populations with sensory sensitivity differences, such as Asperger syndrome (18), healthy populations with anxiety (19,20), and pain catastrophising behaviours (20).

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It is hypothesised that trait sensory hypersensitivity characteristics may be linked to CS through heightened 'natural' sensitivity to sensory stimuli. Furthermore, sensory stimuli may be interpreted as threatening by individuals high in trait anxiety (12,21,22) which in turn may further heighten sensory sensitivity. Four personality types have been described by previous authors based on trait anxiety and defensiveness measures (11). Individuals with each of these four personality types have been found to respond to threat-related stimuli in different ways (12,21-24) and this may have an impact on the extent of CS experienced. Weinberger's four personality types (11) are: 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 has been proposed that individuals with high trait anxiety personality types possess cognitive biases which would influence their perception of, and response to, sensory stimuli (12). These cognitive biases are 1) selective attentional bias (attention is drawn towards threatening stimuli), 2) interpretive bias (stimuli are interpreted as threatening) and 3) negative memory bias (recall of threatening situations more than neutral ones). Individuals with the defensive high anxious personality type tend to selectively attend towards sensory stimuli and interpret them as threatening (12,25). These individuals are significantly more likely to remain in the care system and utilise a variety of treatment options (26). The opposite is so for individuals with low trait anxiety personality types. The repressor personality type, however, self-reports low anxiety yet is prone to the physiological arousal of high state anxiety, and tends to avoid negative affect, believing stimuli are not threatening (12,24).

A recent pilot study (27) found a high prevalence of repressors and trait sensory hypo-sensitivity profiles among a group of people with NSCLBP with predominant CS pain, and

who scored low on measures of CS symptoms (Central Sensitisation Inventory (CSI) (3,4) score < 40). However, being a pilot study numbers were small, and this finding requires further investigation.

It was therefore anticipated that there might be a high prevalence of trait sensory hyper-sensitivity profiles and defensive high anxious personality types in a group of people with NSCLBP and predominantly CS pain, particularly in the high CSI-scoring sub-group (CSI ≥ 40). Furthermore, a high prevalence of repressors and trait sensory hypo-sensitivity profiles in the low CSI-scoring subgroup (CSI < 40) was anticipated.

The aims of this study were to investigate the prevalence of four personality types including extreme sub-groups, and extreme scores of four trait sensory profiles, across a group of people with predominantly CS pain in a NSCLBP population, and to compare these between the low- (CSI < 40) and high- (CSI ≥ 40) CSI sub-groups.

Methods

This study is presented according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement (28).

Design

This was an international cross sectional observational study (29) of a NSCLBP population with predominantly CS pain. Ethical approval was obtained from the University (ref:1205),

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participating hospitals in Ireland, the National Health Service (NHS) in England (IRAS REC

no.:15/NW/0378), and the Northern Y Ethics Committee, New Zealand

Sample

The sample size of n = 165 was calculated based on the requirements of the concurrent

primary study ((30), *submitted*). This was done by taking the mean sample size of three,

each calculated using suggested sample size formulae (31,32), with a power of 80% and

alpha (α) set at 0.05. A post-hoc power analysis confirmed that the sample size in the

current study was sufficient (13 per variable), (33).

Recruitment

Consecutive individuals with NSCLBP were identified by their physiotherapists, who were

experienced in chronic pain and central sensitisation, as being most likely to be experiencing

predominantly CS pain, based on their working knowledge of CS pain. Recruitment was

based on strict inclusion criteria for adults (age 18 to 64) with chronic (>6 months) non-

specific (no identifiable tissue pathology present to explain the pain) low back pain.

Furthermore, the current published clinical criteria for the identification of predominantly

CS pain, to the exclusion of neuropathic and nociceptive primary pain presentations, were

used as inclusion criteria (5,34); (Table 1). Recruitment took place from physiotherapy and

pain outpatient clinics in Ireland, England and New Zealand between July 2015 and March

2017.

Table 1: Inclusion and exclusion criteria given to all physiotherapy health care providers involved in participant recruitment.

Inclusion Criteria
• Aged 18-64 years inclusive
• Reported low back pain most days for more than 6 months
• No clear diagnosis as to the specific source of the pain (such as malignancy/ infection/ inflammatory disease like ankylosing spondylitis etc.) and where anti-inflammatory (NSAID) medication had been used these had not been found to be significantly helpful for the pain
• Pain disproportionate to the current extent of the injury or pathology
• Pain in variable areas around the back +/- other body parts and that was not always in the same place, with a pain distribution that was not neuro-anatomically logical
• Non-predictable pain patterns and responses to various treatments.

Exclusion criteria
• Pain that is predominantly neuropathic in origin (determined using the S-LANSS neuropathic pain score)
• Pain that is predominantly nociceptive in origin (clear aggravating / easing factors and responds well to NSAIDs if used)
• Pregnancy and/or having given birth in the past 12 months
• Spinal surgery within the last 12 months
• Any inflammatory spondyloarthropathy, neurological disease, cardiac, respiratory, metabolic or endocrine disorder

Participants satisfying the inclusion criteria were provided with a participant information

sheet. Consent was obtained at their subsequent visit to the clinic by the same clinician.

Participants completed four self-assessed questionnaires supervised by the clinician. For

omitted or ambiguously answered questions, participants were telephoned where possible

by an independent administrator to clarify responses, reducing the risk of any primary-

researcher influence.

Outcome Measures

Central Sensitisation Inventory (CSI)

The CSI (3) (4) measures the extent to which the individual's symptoms are likely to be attributable to CS. Part A was utilised, which has 25 symptom related items scored on a Likert scale (0-4, score range 0-100). Part B was used to identify those with concurrent fibromyalgia. The CSI has been shown to be valid and reliable (3) with a test-retest reliability of 0.82 and Cronbach's Alpha of 0.88, sensitivity of 81% and specificity of 75% (4). A cut off score of 40 was used to identify low and high CS symptoms (35).

Adolescent / Adult Sensory Profile questionnaire (AASP)

The AASP is a 60-item questionnaire that measures two components of sensory processing function, neural thresholds to sensory stimulation and active or passive behavioural responses to sensory over- or under-stimulation (36).

The AASP identifies four trait sensory profiles of adolescents and adults based on Dunn's original model of sensory processing (10). The AASP combines the sensory thresholds with behavioural response continua to provide a summary score for each sensory profile: Sensory Sensitive (low neural threshold, passive adaptive response), Sensation Avoidance (low neural threshold, active adaptive response), Low Registration (high neural threshold, passive adaptive response) and Sensation Seeking (high neural threshold, active adaptive response) (Table 2). Scores in each sensory profile item range from 1 to 5 based on a Likert scale of 'almost never' to 'almost always', respectively, with a total score for each profile of 75 on a scale from 'much less than-' to 'much more than most people'. Normal values have

previously been established in a healthy population (n= 495), aged between 18 and 64 years (36). Internal reliability (coefficient alphas) for each sensory profile is 0.81 for Sensory Sensitive, 0.66 for Sensation Avoiding, 0.82 for Low Registration and 0.79 for Sensation Seeking (36).

Table 2: Sensory profiles: Sensory Profiles identified by the Adult / Adolescent Sensory Profile Questionnaire (Adapted from (30)).

		Adaptive behavioural response	
		Active	**Passive**
Stimulus Threshold	**High**	Sensation Seeking	Low Registration
	Low	Sensation Avoiding	Sensory Sensitive

State-Trait Anxiety Inventory (STAI)

The STAI (trait section; (37,38), measures trait anxiety, an enduring, relatively stable characteristic indicating the likelihood of the person responding to perceived threats with increased state anxiety. Trait anxiety has been found to be associated with sensory sensitivity to stimuli (39). It is a self-assessed 20-item questionnaire, using a 1 to 4-point Likert scale with answers ranging from "not at all" to "very much so" respectively, with a maximum score of 80 (with higher scores indicating higher trait anxiety). 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 timeframe (38) .

Marlowe Crowne Social Desirability Scale (MCSDS)

The MCSDS (40) measures defensiveness / social desirability. The Short Form of the MCSDS was used (41) which is a 10-item self-reported questionnaire with "true" or "false" responses with a scale of 0-10 (with higher scores indicating greater defensiveness). (42) reported an internal consistency alpha coefficient of 0.66 and a correlation coefficient of r = 0.90 (p < 0.001) between the 10 item MCSDS and the original 33 item MCSDS (40). The short form version was chosen in preference to the longer version for its time management advantage.

The MCSDS combined with the STAI-T indicate the personality type of the individual (11) described earlier and summarised in Table 3.

Table 2: Personality types identified by combining the Trait section of the State-Trait Anxiety Inventory, and the Marlowe-Crowne Social Desirability Scale (MCSDS).

Social Desirability / Defensiveness

		High	**Low**
Trait Anxiety	**High**	Defensive High Anxious	High Anxious
	Low	Repressor	Low Anxious

Data Management

Data were pseudo-anonymised prior to data analysis by removing the front page containing the identifiable information and allocated a research number. Any missing data items were entered using individual mean scores per outcome-measure.

Analysis

Data were analysed using IBM SPSS Statistics version 22 (43). The primary outcome measure was the CSI.

CSI score

Descriptive statistics were used to describe the demographics and the range of CSI scores across the study population. The high- and low- CSI sub-groups were identified using a cut-off score of ≥ 40 on the CSI (4). The prevalence of extreme scores from each sensory profile in the high- and low- CSI sub-groups was calculated. Extreme scores were identified as one standard deviation either side the mean (±1SD). Prevalence was compared to healthy population data (36) from the AASP User Manual.

Chi Squared (χ^2) calculations were used to determine whether differences between the observed and expected calculations for each sensory profile were statistically significant ($p > 0.05$). Proportions of the four personality types were calculated in the two CSI sub-groups and chi squared calculations were used to establish any statistically significant proportional differences.

Personality type

The method chosen for splitting the STAI and MCSDS scores for identification of the four personality types in the current study was to reflect the same method used by previous authors (36) for identifying the four sensory profiles. Personality types were identified using a cut off score based on means and SDs identified in normative data (38,44,45). Using normative data as a reference has been done by previous authors (46). Other authors have also used a cut off score above and below which identified high or low anxiety and

defensiveness scores respectively (47). Therefore, the four personalities were identified as follows: high anxious, STAI ≥ 39 and MCSDS ≤ 5; defensive high anxious, STAI ≥ 39 and MCSDS > 5; low anxious, STAI < 39 and MCSDS ≤ 5; and repressor, STAI < 39 and MCSDS > 5. Heterogeneity of personality types was tested using Levene's test. To identify extreme sub-groups within each personality type, extreme scores were calculated using the SDs from normative data for the STAI (38,44) and MCSDS (46) scales as follows: STAI ≤29 for low anxious and ≥49 for high anxious and MCSDS ≤4, low defensiveness and MCSDS ≥8, high defensiveness. The independent t-test and effect sizes were used to test for differences in the mean trait anxiety scores between the high- and low-CSI sub-groups, in each personality type.

Results

Demographics

A total of n=165 participants (n = 39 male) were recruited after n = 12 potential participants has refused to participate (5 = male, n = 6 from Ireland, n = 1 from England and n = 5 from New Zealand). Recruitment took place from eight physiotherapy and pain outpatient clinics in New Zealand (n = 82), three in England (n = 36) and two in Ireland (n = 47). Age ranged from 18-64 years, (mean = 45 ±12). CSI scores were normally distributed and ranged from 19 to 79, mean = 50 (95% CI 47.97 - 52.23).

Participants consisted of high and low CSI sub-groups. The high CSI (CSI ≥ 40) sub-group consisted of n = 129 individuals, mean CSI score = 55 (SD +-11), mean age = 46 (SD +-11.7), n = 28 male and n = 22 diagnosed with concurrent fibromyalgia (n = 20 female). The low CSI (CSI < 40) sub-group consisted of n = 36 individuals, mean CSI score = 32 (SD +-5.5), mean age =

49 (SD +-10.0), n = 11 male and n = 2 diagnosed with concurrent fibromyalgia (female). There

was no significant difference in mean age between the two CSI sub-groups (t= 1.5, p< 0.05),

nor in the distribution of male / female participants ($x^2_{(1)}$ = 1.22, p<0.05).

A total of n=112 (68%) participants were taking one or more pain-related medication (Table

4). Almost a third of the group were not taking any medication (n = 53, 32%).

Table 4: Mean Central Sensitisation Scores for each medication group used by the participants (N=165) with NSCLBP and CS pain.

Medication group	Participants (N=)	Mean CSI score (±SD)
Anti-convulsants	38	57 (14)
Antidepressants: SS(N)RI	24	55 (15)
Tricyclics	29	54 (10)
Analgaesics	48	53 (15)
Opioids	23	53 (14)
NSAIDs	37	50 (15)
Antispasmodics	8	49 (17)
Anti-anxiety (SARI)	7	49 (10)
No medication	53	44 (11)

Anti-anxiety: Serotonin Antagonist & Reuptake Inhibitors (SARI)
Non-steroidal anti-inflammatories
Antidepressants: Selective Serotonin (Norepinephrine) Reuptake Inhibitors SS(N)RI

The AASP provides a summary score for all four sensory profiles; these are presented in two groups based on sensory hyper- and hypo-sensitivity:

Sensory hyper-sensitivity group: Sensory Sensitive and Sensation Avoiding profiles.

Participants in the high-CSI sub-group (CSI ≥ 40) had significantly more extreme scores in both the Sensory Sensitive (67%; $\chi^2_{(2)}$ = 182.63, p < 0.001) and Sensation Avoiding profiles (53%; $\chi^2_{(2)}$ = 102.53, p < 0.001) (Tables 5 and 6).

Conversely, participants in the low-CSI sub-group (CSI < 40) showed no significant difference in prevalence of extreme scores (Sensation Avoiding: 11%, $\chi^2_{(2)}$ = 2.5 p > 0.05; Sensory Sensitive: 14%, $\chi^2_{(2)}$ = 5.72, p > 0.05).

Table 5: Prevalence of extreme sensory sensitivity scores in the low and high CSI Groups.

Sensory Sensitive Profile					
		Distribution of participants			P=
		>-1SD	≤±1SD	>+1SD	
CSI >=40 N=129	N=	3	40	86	P < 0.001
	Range	20-24	35-55	42-69	
	Mean (±SD)	22 (2)	45 (9.9)	51 (6.2)	
	Prevalence (%)	2	31	67	
CSI<40 N=36	N=	4	27	5	p > 0.05
	Mean (±SD)	22 (3.9)	34 (7)	47 (2.1)	
	Range	16-25	27-41	42-50	
	Prevalence (%)	8	78	14	

CSI = Central Sensitisation Inventory Score
SD = Standard Deviation

Table 6: Prevalence of extreme Sensation Avoiding scores in the low and high CSI groups.

Sensory Avoiding Profile					
		Distribution of participants			P=
		>-1SD	≤±1SD	>+1SD	
CSI >=40 N=129	N=	8	53	68	p < 0.001
	Range	18-26	31-53	42-70	
	Mean (±SD)	24 (2.4)	42 (11)	51 (6.8)	
	Prevalence (%)	6	41	53	
CSI <40 N=36	N=	5	27	4	p > 0.05
	Mean (±SD)	22 (2.8)	34(7)	49 (3.9)	
	Range	17-24	27-41	44-52	
	Prevalence (%)	14	75	11	

CSI = Central Sensitisation Inventory Score
SD = Standard Deviation

Sensory hypo-sensitive group: Sensation Seeking and Low Registration profiles:

In participants in the high-CSI sub-group (CSI>=40), low extreme scores for Sensation Seeking were significantly more prevalent (47%; $\chi^2_{(2)}$ = 71.83, p < 0.001) but not in the low-CSI sub-group (Table 7).

Table 7: Prevalence of extreme Sensation Seeking sensory profile scores in the low and high CSI groups.

Sensory Seeking Profile					
		Distribution of participants			P=
		>-1SD	≤±1SD	>+1SD	
CSI >=40 N=129	N=	61	58	10	p < 0.001
	Range	18-42	35-53	57-63	
	Mean (±SD)	36 (5.4)	44(9)	59 (1.9)	
	Prevalence (%)	47	45	8	
CSI <40 N=36	N=	7	26	3	p > 0.05
	Mean (±SD)	37 (3.3)	47(7)	60 (2.1)	
	Range	31-42	40-54	58-62	
	Prevalence (%)	20	72	8	

CSI = Central Sensitisation Inventory Score
SD = Standard Deviation

In participants in the high-CSI sub-group (CSI>=40), high extreme scores were significantly more prevalent in Low Registration sensory profiles (63%; $\chi^2_{(2)}$ = 165.07, p < 0.001); (table 8).

Unlike the other sensory profiles in the low CSI (CSI<40) sub-group, there was a significantly greater prevalence of both high (25%) and low (22%) extreme scores for the Low Registration sensory profile ($\chi^2_{(2)}$ = 9.12, p < 0.05), (table 8).

Table 8: Prevalence of extreme Low Registration sensory profile scores in the low and high CSI groups.

| Low Registration Profile					
		Distribution of participants			P=
		>-1SD	≤±1SD	>+1SD	
CSI >=40 N=129	N=	6	42	81	p < 0.001
	Range	17-22	29-47	36-60	
	Mean (±SD)	20 (2.1)	38(9)	44 (6.3)	
	Prevalence (%)	4	33	63	
CSI <40 N=36	N=	8	19	9	P < 0.05
	Mean (±SD)	21 (2.7)	30(8)	40 (4.6)	
	Range	15-23	22-38	36-50	
	Prevalence (%)	22	53	25	

CSI = Central Sensitisation Inventory Score
SD = Standard Deviation

Personality Types

Across the whole group of people with NSCLBP and predominant CS, the largest proportion of individuals were defensive high anxious (n = 75, 45%), then the high anxious (n = 43, 26%) and repressor (n = 41, 25%) groups. The lowest proportion was the low anxious group (n = 6, 4%), none of whom were in the extreme score ranges (Figure 1). The four personality type groups were significantly distinguishable from each other in their trait anxiety and defensiveness scores: STAI, F(3,161) = 10.19, p = 0.00 and MCSDS, F(3,161) = 3.51, p = 0.017. The proportion of low and high CSI scores was 22% and 78% respectively (table 9). There was a significantly greater prevalence of repressors in the low CSI sub-group ($\chi^2_{(1)}$ =12 P<0.01). Although the prevalence of people with the defensive high anxious and high anxious personality types were comparable between the low- and high-CSI sub-groups,

there was a significant difference in proportional distribution of the extreme defensive high anxious personality type: 100% of these individuals scored over 40 on the CSI ($x^2_{(1)}$ = 21.7, p < 0.01).

Figure 1: The proportions and prevalence of personality types, including the extreme personality type sub-groups, within the low and high CSI sub-groups in the non-specific chronic low back pain population with central sensitisation.
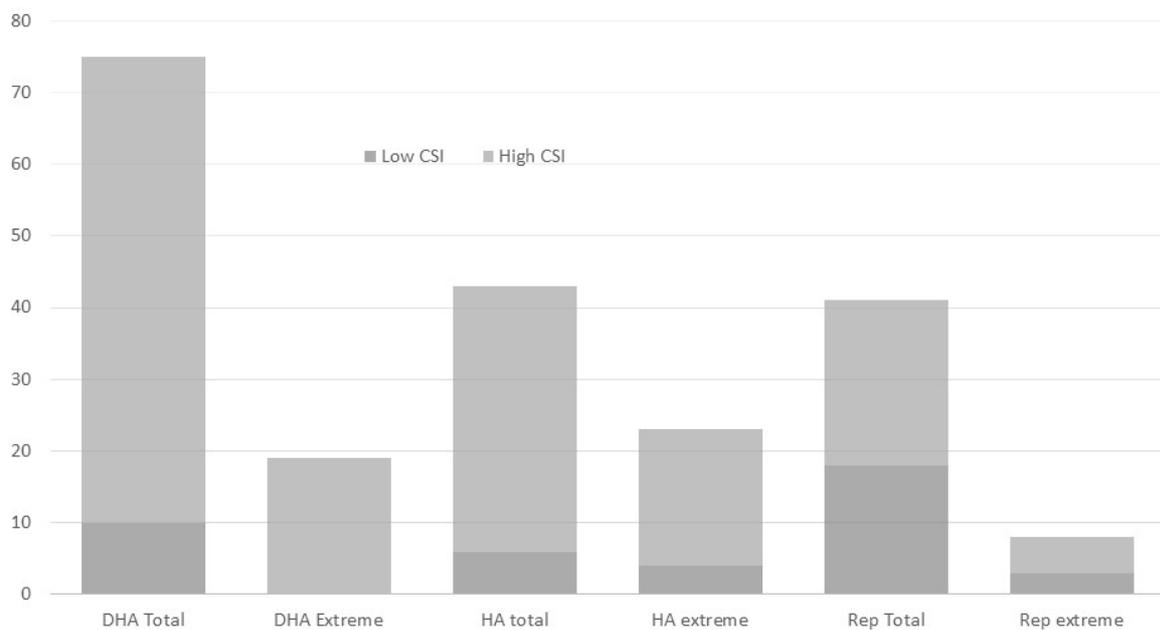
Furthermore, the defensive high anxious group had significantly higher levels of trait anxiety in the high- compared with the low-CSI sub-group (U = 3.0, p=0.000). There were no significant differences in the trait anxiety scores in the high anxious and repressor individuals, nor in defensiveness scores for all the personality types, between low- and high-CSI sub-groups.

Discussion

This the first and largest study to observe the prevalence of trait sensory profiles and personality types in people with NSCLBP and predominant CS. Furthermore, it is also the first to observe the prevalence of low- and high-CSI sub-groups in people with clinically identified predominant CS pain.

Extreme trait sensory hypersensitivity profiles in people with high-CSI scores suggests that a significant number of people with NSCLBP and CS have a low neurological threshold for sensory stimulation and either a passive- (Sensory Sensitive) or an active- (Sensation Avoidance) adaptive response to sensory over-stimulation. The AASP claims to measure trait preferences (36) which imply that the characteristics of sensory hypersensitivity were present pre-morbidly. Other studies have suggested that sensory sensitivity may be a characteristic of individual differences in healthy populations (48-50) and a pre-morbid risk factor (identified using QST) in people who later developed musculoskeletal CS pain (51-54). The results of the current study may lend support to the concept of pre-existing trait sensory sensitivity.

Also identified in the high-CSI group were extreme scores of trait sensory hypo-sensitivity (Low Registration and Sensation Seeking) profiles, which is unexpected when related to the hypersensitive nature of CS.

Other studies have also discussed sensory hypo-sensitivity (mis-localisation and reduced sensory discrimination) in populations with NSCLBP (55,56). The prevalence of sensory hypo-sensitivity to various sensory stimuli has been estimated at 25 - 50% of individuals

with (unspecified) chronic musculoskeletal pain (57,58). Sixty-eight percent of the current study participants with NSCLBP and CS had extreme scores in the Low Registration sensory profile, more than that found in other studies (57). This increase may be attributable to the homogeneous sample in this study specific to CS pain and NSCLBP, and to the passive adaptive response nature of the Low Registration profile. Clinically this may mean that individuals with NSCLBP and CS with a high neurological threshold for sensory stimulation need to receive greater levels of sensory input to function healthily (13), which may in turn influence treatment programmes for these individuals. Furthermore, extreme in the Low Registration profile may have implications for the use of QST to identify CS in people with NSCLBP in the event of some senses being hypo-sensitive, which could be misleading.

Personality Types

The way participants respond to pain may be influenced by their personality type (24). The largest proportion of participants in the current study were defensive high anxious individuals (45%). This was similar to a population with chronic fatigue syndrome (46%,(47), a chronic condition characterised by CS (59) and higher than that found in a healthy population (47). Nineteen (12%) participants in the current study were in the extreme sub-group for defensive high anxious personality type, similar to another study (46) (13%) of target shooters and hockey players with low back pain but lower than another chronic low back pain group where CS pain was not specified (26%) (60). However, the latter study used a clinical-population-based cut-off score, using tertiary splits at 33% and 66%, where STAI ≥ 42. This was lower than the current study normative-based cut off score, using >+- 1SD, of STAI ≥ 49, which may explain the difference in prevalence found.

All extreme defensive high anxious individuals scored high on the CSI (CSI ≥ 40). This may reflect the proneness of these individuals to attend to pain related symptoms (22), show persistence in their seeking of multiple medical interventions (61) and interpret stimuli as threatening (24,61) significantly more than the other three personality types.

Implications

The clinical implications for people with NSCLBP and CS are that identification of these profiles may guide management accordingly. For example, pain neuroscience education e.g. (62) may reduce threat perception in the defensive high anxious and anxious individuals. Furthermore, identification of active or passive behavioural patterns in response to sensory stimulation, using the sensory profiles, may help the individual to modify their behaviours.

The current study findings of a sub-group of low- CSI people with NSCLBP and clinically identified, predominant CS pain supports the latest clinical guidelines recommended by (5), in which clinical criteria can be used to identify CS without there needing to be a score of CSI ≥ 40. It is proposed that a low CSI score should not discount those individuals as experiencing CS pain when 1) there is no evidence for predominant nociceptive or neuropathic pain mechanisms and 2) they have a repressor personality type and/or an extreme Low Registration sensory profile score.

Strengths and Limitations

Strengths of this study include the methodology, which followed the current clinical recommendations for identifying patients with NSCLBP and predominantly CS pain, thereby limiting heterogeneity within the sample. Bias was limited by ensuring participants were

recruited by multiple participating clinicians across three countries and two continents, optimizing external validity. The study recruited more female than male participants, reflecting epidemiological studies showing chronic low back pain is more prevalent among women (63).

Potential weaknesses included a lack of demographic information available from participating clinicians regarding the participants who refused to participate. Limitations may have been caused by the likely response bias related to questionnaires by different personality types and a lack of blinding of the researcher to some participants.

Conclusion

This study is the first to show that 1) extreme trait sensory profiles and personality types are related to the extent of CS pain and 2) low CSI scores are observable in people with NSCLBP who are clinically diagnosed with predominantly CS pain. Extremes in defensive high anxious personality type and the Sensory Sensitive profile may play an aetiological role in CS pain and this requires further investigation. Furthermore, low self-report levels of CS symptoms (CSI < 40) should not exclude the possibility of a predominant CS pain mechanism in people with NSCLBP. Further investigations are required into which particular senses (of those investigated in the AASP) may be hypo-sensitive, and this may in turn guide individual treatment strategies.

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