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Cross-Cultural Adaptation and Validation of the Central Sensitization Inventory Among Chinese Patients with Chronic Non-Specific Low Back Pain

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Purpose: This research aims to develop and validate the Chinese version of the Central Sensitization Inventory (CSI-CV) for patients suffering from chronic non-specific low back pain (CNSLBP). The study evaluates both the validity and reliability of the CSI-CV.

Patients and Methods: The cross-cultural adaptation of the scale strictly adhered to the principles of Bombardier and Beaton. Initially, two professors of Chinese-English translation independently translated the original CSI scale into the target language, and then collaborated with an expert in cross-cultural adaptation to merge into a single version. This version was back-translated into English by two professors whose native language is English. Following this, the scale underwent preliminary review by bilingual experts and the research team, and was preliminarily tested, ultimately culminating in the formation of the CSI-CV version. A total of 310 patients with CNSLBP completed the CSI-CV, while 50 of them repeated the survey one week later to test the stability of the scale. The CSI-CV's reliability, validity, and internal consistency were assessed through exploratory factor analysis (EFA), correlation coefficients, and Cronbach's α.

Results: EFA revealed five distinct factors from the 25 CSI-CV items, covering physical symptoms, emotional distress, fatigue and sleep disturbances, headaches and jaw symptoms, and urinary issues, with a total explained variance of 60.24%. The Cronbach's α was 0.910, and the intraclass correlation coefficient (ICC) was 0.924, indicating strong reliability. Moderate correlations were observed between CSI-CV scores and Five-Level EuroQol Five-Dimensional Questionnaire ($r = -0.515$), the Brief Pain Inventory ($r = 0.586$) and Oswestry Disability Index ($r = 0.416$), demonstrating significant associations with these measures.

Conclusion: The CSI-CV exhibits excellent internal consistency, factor structure, and reliability. Its successful cultural adaptation offers valuable insights for improving treatment approaches for patients with CNSLBP.

Keywords: central sensitization inventory, chronic non-specific low back pain, Chinese, cultural adaptation

Introduction

Low back pain, defined as musculoskeletal discomfort between the 12th rib and the gluteal crease, is among the most prevalent musculoskeletal conditions worldwide.[1,2] Epidemiological evidence indicates a growing incidence of low back pain across all ages, with an estimated 70%-85% of individuals experiencing pain in the lower back or legs at some point in their lives. The lifetime prevalence of low back pain is approximately 40%.[3,4] Based on its origin, low back pain is categorized into specific and non-specific types.[5] Specific low back pain is associated with infections, trauma, or structural issues, while non-specific low back pain refers to functional impairment in the lower back without a clear structural cause. When symptoms persist for more than three months, the condition is classified as chronic non-specific low back pain (CNSLBP), which accounts for the majority over 90% of cases.[6,7] This chronic pain condition severely

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restricts movement and is a primary contributor to disability among the elderly, imposing substantial financial strain on families and the broader community.[8,9]

Pain perception is a result of intricate communication between the peripheral and central nervous systems.[10,11] Research has demonstrated dysregulation in both ascending and descending pathways in chronic pain patients, resulting in symptoms such as allodynia, hyperalgesia, and hypersensitivity.[12] Recently, the notion of central sensitization (CS) has gained widespread attention. CS is characterized by heightened sensitivity of the nociceptive neurons within the central nervous system, whereby regular or sub-threshold stimuli can lead to an escalation in pain perception and an increased sensitivity to stimuli that are typically not painful.[13] It is considered a key pathophysiological mechanism contributing to mechanical hyperalgesia and allodynia in chronic pain conditions,[14] and is thought to play a role in several chronic musculoskeletal disorders, including low back pain,[15,16] osteoarthritis,[17,18] rheumatoid arthritis,[19] and fibromyalgia.[20] While CS is not present in all CNSLBP patients, when it does occur, it can significantly affect the clinical picture, disease course, and treatment response.[21] CS is thus recognized as a major factor in persistent pain and poor outcomes in CNSLBP.[22,23] Therefore, it is critical for clinicians to detect CS early in these patients to implement appropriate interventions and treatment strategies.

To objectively assess CS, a range of diagnostic tools has been developed, including Quantitative Sensory Testing (QST)[24] and functional magnetic resonance imaging (fMRI).[25] Despite their usefulness, these methods are often complex, expensive, and time-consuming.[26] Considering the vast patient population in China and the unequal distribution of medical resources,[27–29] There is a significant demand for practical, economical, and efficient diagnostic instruments, including the Central Sensitization Inventory (CSI). The CSI is designed to evaluate central nervous system sensitization and is widely used in both clinical and research settings for pain management. It enables clinicians to assess a patient's pain perception and regulation by analyzing responses to sensory stimuli.[30] The CSI focuses primarily on pain sensitivity, thresholds, and duration, and its proper use requires specialized training to ensure accurate and reliable results. In clinical practice, the CSI facilitates healthcare professionals in gaining a deeper comprehension of a patient's pain profile, enabling them to customize therapeutic approaches accordingly.

Translations and validations of the CSI have been carried out for patients with chronic low back pain (CLBP) across various countries and regions, the scale was found to be valid and reliable in these studies.[31–35] Studies suggest that the number of underlying factors in the CSI dimensions may vary between different language versions.[36] However, to date, no cross-cultural adaptation or validation of the CSI has been conducted for patients with CNSLBP in Mainland China. The lack of a validated Chinese version means that researchers and clinicians currently do not have access to this tool. Nevertheless, a culturally adapted CSI could greatly assist healthcare providers in making more accurate clinical decisions.[37,38] This is particularly important in regions with diverse cultural backgrounds, where patients may have varying attitudes toward pain, healthcare practices, and treatment approaches.[39] Therefore, ensuring the cross-cultural validity and applicability of the CSI would significantly enhance diagnostic accuracy, improve treatment outcomes, and ultimately improve overall patient care.[40] The purpose of this investigation is to culturally adapt the Cross-Cultural Adaptation of Psychological Assessments CSI for use among Chinese-speaking populations and to assess its reliability among patients afflicted with CNSLBP.

Materials and Methods

Participants and Data Collection

This prospective study was approved by the Ethics Committee of Xi'an Honghui Hospital (approval number:202209026). All experimental protocols were conducted in accordance with the ethical standards of the Declaration of Helsinki.[41] Participants received both oral and written explanations regarding the study's procedures, potential benefits, risks, and the option to withdraw from the study at any point without consequence. Before commencing the research activities, written informed consent was secured from each participant. and strict confidentiality of personal data was maintained throughout the study.

Between July 2023 and August 2024, patients with chronic non-specific low back pain were recruited from the Orthopedic Department of Xi'an Honghui Hospital, Shaanxi Province, China, following diagnostic criteria based on

relevant literature.[42,43] The inclusion criteria for participants were as follows:[44] (a) recurrent low back pain lasting more than 3 months; (b) diagnosis of chronic non-specific low back pain confirmed by an orthopedic specialist; (c) age 18 years or older, irrespective of gender; (d) cognitive ability to complete the required questionnaires; (e) fluency in Mandarin; and (f) Signed consent was obtained from participants or their representatives before any study procedures. Exclusion criteria included: (a) failure to meet the diagnostic criteria for chronic non-specific low back pain; (b) pain caused by other factors such as infections, tumors, osteoporosis, rheumatoid arthritis, or vertebral fractures; (c) severe comorbidities that could significantly affect daily activities or influence scale scores, such as serious cardiovascular, gastrointestinal, or urinary conditions; (d) inability to effectively communicate or any researcher-assessed inability to fully comply with study protocols; (e) history of severe neuropsychological or psychiatric disorders that might hinder participation.

Experienced interviewers facilitated the completion of self-assessment questionnaires, providing guidance to participants throughout the process. Each participant also filled out a general demographic questionnaire that collected information on age, height, weight (calculated as body mass index), gender, marital status, living arrangements, and education level. Additionally, participants completed three standardized assessments: the EuroQol five-dimensional questionnaire (EQ-5D), the Brief Pain Inventory (BPI), and the Oswestry Disability Index (ODI). Upon completion of the questionnaires, a thorough examination was undertaken to detect any unanswered questions, and participants were politely requested to supply the required details for any skipped inquiries.[45] Furthermore, 50 participants were randomly selected to repeat the same questionnaires seven days after their initial completion.[46]

Sample Size

To ensure an adequate sample size, it is commonly recommended that each item on a scale receives between 5 and 10 responses, with the total number of responses being 5 to 10 times the number of items on the scale.[47] When multiple scales are involved, the sample size should be determined based on the scale with the highest item count. Following these guidelines, our initial estimate indicated that a minimum of 100 participants would be required for this study.[48] However, after further consideration, we concluded that a final sample size of 250 or more participants would be more appropriate.

Translation and Cross-Cultural Adaptation

The cultural adaptation process of CSI strictly adhered to the guidelines of Bombardier and Beaton.[49] Prior to embarking on the cross-cultural translation, a multidisciplinary team of experts was convened to oversee the entire translation process, ensuring precision and accuracy at every step. This team included four translation experts, two orthopedic spine specialists, one methodology expert, and one physiotherapist. First, two Chinese-native professionals with qualifications in both Chinese and English translation independently translated the CSI scale from English into Simplified Chinese. The backgrounds of the two translators are as follows: one is an experienced orthopedic spine surgeon with medical expertise, and the other is a professional translator without a medical background but possessing translation qualifications. After the forward translation, an expert proficient in cross-cultural adaptation procedures collaborated with both translators to integrate and optimize their translations, resulting in a coherent and culturally adapted version. Subsequently, the initial Chinese version was back-translated into English by two professors who are native English speakers and possess qualifications in Chinese-English translation, despite not having a medical background. Through this process, consensus was reached to ensure the back-translation matched the meaning of the original CSI. The purpose of back-translation was to confirm the accuracy and fidelity of the content, ensuring it remained consistent with the source text. Subsequently, all researchers involved in the process held a meeting to address any discrepancies or ambiguities that arose during translation and adaptation. This collaborative effort resulted in the initial CSI-CV. To further improve the CSI-CV, we conducted a preliminary test with 20 patients suffering from CNSLBP, gathering crucial feedback for refinement. After thorough discussion and the resolution of issues that emerged during the trial phase, the final version of the CSI-CV was completed.

Instruments

The CSI-CV

The CSI-CV is divided into two parts: A and B.[50] Within Part A, individuals evaluate a total of 25 symptom items, scoring the occurrence of each symptom on a scale ranging from 0 to 4 (Never = 0, Rarely = 1, Sometimes = 2, Often = 3, Always = 4), with a maximum achievable score of 100. Participants' scores from Part A are categorized into five severity levels: subclinical (0–29), mild (30–39), moderate (40–49), severe (50–59), and extreme (60–100). Part B evaluates whether participants have been diagnosed with any of the 10 conditions associated with Central Sensitization Syndrome (CSS), but does not involve scoring. Participants are asked to respond to two questions: (1) whether they have received a medical diagnosis of any of these conditions, and (2) if applicable, the year they were diagnosed.

Five-Level EuroQol Five-Dimensional Questionnaire (EQ-5D-5L)

The EQ-5D-5L is a widely recognized self-report tool for assessing quality of life.[51,52] It evaluates health status across five dimensions: Mobility, Self-Care, Usual Activities, Pain/Discomfort, and Anxiety/Depression. Respondents indicate their current health level, ranging from no issues to extreme problems. This tool is pivotal in medical research, health economics, and policy, offering a succinct yet comprehensive health status and life quality assessment.

Brief Pain Inventory (BPI)

The BPI is a key tool for assessing pain severity and its effects on patients' lives.[53] It measures both the intensity of pain and its impact on daily life. Patients rate their pain levels over the last 24 hours and describe how pain affects their activities, mood, and well-being. The BPI's comprehensive approach to pain assessment helps healthcare providers understand the physical, emotional, and social aspects of a patient's condition. This tool is invaluable for clinical practice and research, enabling more targeted and effective pain management strategies.

Oswestry Disability Index (ODI)

The ODI effectively measures functional impairment in spinal disorders, notably lumbar spine conditions.[54] It rates daily activities like walking and sitting on a 6-point scale, summarizing scores to indicate disability levels. Widely used in clinical practice and trials, the ODI helps assess treatment efficacy for lumbar spine patients.

Statistical Analysis

The Kolmogorov-Smirnov test was applied to assess whether the total scores from the CSI-CV, EQ-5D, ODI and BPI were normally distributed. Furthermore, descriptive statistics were used to analyze and present the study participants' demographic and clinical features. Continuous variables with a normal distribution were expressed as mean ± SD, whereas non-normally distributed ones were shown as median (interquartile range). Categorical variables were expressed as frequency (percentage). In instances where variables exhibited a normal distribution, t-tests and one-way ANOVA with Bonferroni correction were implemented to discern variations in CSI-CV scores across different participant attributes. All statistical analyses were performed utilizing SPSS version 27.0, setting the significance level at 0.05.

Floor and Ceiling Effects

The presence of floor and ceiling effects in the CSI-CV was examined by evaluating whether the scores indicated that more than 15% of the participants achieved either the minimum or maximum possible scores. If such a proportion of participants scored at either extreme, the respective dimension of the CSI-CV was considered to exhibit floor or ceiling effects.[55]

Internal Consistency Reliability

Internal consistency reliability, often referred to as the internal consistency coefficient, evaluates the degree of agreement among multiple items within the same dimension. Cronbach's alpha is the most widely utilized coefficient for assessing the internal consistency of scales. Consequently, Cronbach's alpha was employed to evaluate the internal consistency reliability of the CSI-CV, BPI, EQ-5D, and ODI. An alpha coefficient below 0.70 indicates poor or unacceptable internal

consistency, whereas a coefficient above 0.7 is deemed acceptable, reflecting a high level of internal consistency and inter-item correlation within each dimension.[56]

Items were examined based on their scores and factor loadings derived from Cronbach's alpha analysis. Specifically, items with factor loadings below 0.4 were considered for removal, and subsequent analysis showed that the overall Cronbach's alpha increased after these items were excluded.[45]

Structural Validity

The primary aim of assessing structural validity is to confirm whether the relationships among the items within the scale correspond to the anticipated theoretical model. This evaluation is typically conducted using statistical methods such as factor analysis, which reveals the underlying factor structure of the items and thus assesses structural validity. Given the variability in the factor structure of the CSI across different cross-cultural adaptations, we adopted an exploratory approach to examine the structural validity of the CSI-CV, focusing on identifying the number of factors.

To evaluate the data's appropriateness for analysis, the Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were employed.[57] Additionally, we conducted Exploratory Factor Analysis (EFA) with Promax rotation. EFA serves as a statistical technique aimed at investigating the internal structure of a scale, with the goal of identifying the underlying factor organization by analyzing the correlations and grouping patterns among the items. Promax rotation, a widely used method in factor analysis, facilitates a clearer interpretation of the results by simplifying the factor structure.[58]

Criterion Validity

Criterion validity pertains to the effectiveness of a measurement tool or method in predicting or measuring an outcome variable. In this research, criterion validity of the CSI-CV was assessed by determining Pearson correlation coefficients with scores from the EQ-5D, BPI, and ODI. Prior to analysis, we hypothesized a moderate correlation between the CSI-CV scores and the total scores of the EQ-5D, BPI, and ODI, based on a thorough evaluation of the content of these scales.

The strength of the correlation was interpreted using the following criteria: very strong (>0.80), strong (0.61–0.80), moderate (0.41–0.60), weak (0.21–0.40), and negligible to none (0.0–0.2).[59]

Test–Retest Reliability

Test-retest reliability assesses the consistency of results obtained by administering the same scale to the same group of subjects on two separate occasions. In this study, Intraclass Correlation Coefficients (ICC) were computed using a two-way random effects model. ICC value ranging from 0.5 to 0.75 suggests moderate reliability, values from 0.75 to 0.9 denote good reliability, and those above 0.9 indicate excellent reliability.[60] On the seventh day following the initial questionnaire completion, 50 participants were randomly selected for a follow-up survey.[46]

Measurement Error

The Standard Error of Measurement (SEM) is a measure of reliability, which is determined using the formula $SEM = SD \times \sqrt{(1 - ICC)}$.[61]

Results

Participant Characteristics

A total of 310 participants were recruited for the study, with their demographic details displayed in Table 1.

Cross-Cultural Adaptation and Item Screening Results

The translation process for the CSI-CV was successfully completed, involving both forward and backward translations, with no significant challenges encountered. Exploratory factor analysis indicated that all items had factor loadings greater than 0.4, as detailed in Table 2. Additionally, further analysis demonstrated that the removal of any items did not result in an increase in the Cronbach's α coefficient for the scale. Therefore, there was no need to exclude any items during the item selection phase.

Table 1 Demographic Information of Participants

Items	Total (N=310)
Ages (SD, range)	58.89 years (12.89,22 to 80)
Height (SD, range)	1.64 m (0.07,1.50 to 1.80)
Weight (SD, range)	65.22 kg (9.58,45 to 88)
Body mass index (SD, range)	24.14 kg/m2 (2.98,18.03 to 31.22)
Gender	
Male	106(34.2%)
Female	204(65.8%)
Employment status	
In work	176(56.8%)
Retired	111(35.8%)
Be unemployed	23(7.4%)
Marital status	
Married	256(82.6%)
Unmarried	12(3.9%)
Missing	42(13.5%)
Education	
Primary school or below	152(49.0%)
Middle	42(13.5%)
High	61(19.7%)
University or above	55(17.7%)
Sickness time (month, SD, range)	61.85(63.55, 6 to 360)

Abbreviations: SD standard deviation.

Table 2 Factor Loadings of the EFA with Promax Rotation

Item	Question	F1	F2	F3	F4	F5	Not loading
C9	Pain all over body	0.853					
C2	Muscles stiff/achy	0.780					
C14	Skin problems	0.528					
C18	Tension neck and shoulder	0.514					
C20	Certain smells make dizzy	0.481					
C25	Pelvic pain	0.436					
C6	Need help with daily activity	0.413					
C17	Low energy		0.796				
C16	Sad or depressed		0.791				
C23	Poor memory		0.668				
C3	Anxiety attacks		0.463				
C15	Stress makes symptoms worse		0.455				
C13	Difficulty concentrating		0.414				
C24	Trauma as a child		0.402				
C12	Do not sleep well			0.931			
C8	Easily tired with physical activity			0.730			
C1	Unrefreshed in morning			0.651			
C22	Restless legs			0.462			
C7	Sensitive to bright lights				0.871		
C10	Headaches				0.720		
C4	Grind/clench teeth				0.680		
C19	Pain in jaw				0.536		
C5	Diarrhea/constipation				0.501		
C11	Bladder/urination pain					0.843	
C21	Urinate frequently					0.592	

Abbreviations: EFA, Exploratory Factor Analysis; F1 Physical Symptoms; F2 Emotional Symptoms; F3 Fatigue and Sleep Problems; F4 headache and Jaw Pain Symptoms; F5 Urological Problems.

Prevalence

As presented in Table 3, the CSI-CV Part A scores for the 310 participants in this study ranged from 15 to 60, yielding a mean score of 37.5 (SD = 10.6). Among these individuals, 83 (26.8%) were categorized as having subclinical Central Sensitivity (CS), 99 (31.9%) exhibited mild symptoms, 78 (25.2%) displayed moderate symptoms, and 50 (16.1%) were classified as severe. Furthermore, 53 patients (17.1%) received diagnoses of diseases associated with Central Sensitivity Syndrome (CSS). Notably, patients diagnosed with one type of CSS (50 cases, mean CSI score of 50.36, SD = 6.16) or two types of CSS (3 cases, mean CSI score of 51.33, SD = 13.32) demonstrated significantly higher CSI scores compared to those without CSS diagnoses (257 cases, mean CSI score of 34.84, SD = 9.23; $P < 0.01$).

Floor and Ceiling Effects

The analysis of CSI-CV scores revealed no floor or ceiling effects, as none of the participants' scores reached the minimum or maximum thresholds of the scale.

Internal Consistency Reliability

As shown in Table 4, the CSI-CV demonstrated strong internal consistency, achieving Cronbach's α of 0.910. Additionally, the Cronbach's α coefficients for the dimensions identified through exploratory factor analysis ranged

Table 3 Prevalence Rates of CS Severity Levels and Frequency of Diagnoses

CSI-CV score	N (%)
Subclinical (0–29)	83 (26.8%)
Mild (30–39)	99 (31.9%)
Moderate (40–49)	78(25.2%)
Severe (50–59)	49(15.8%)
Extreme (> 60)	1(0.3%)
Diagnoses	
Restless leg syndrome	2(0.6%)
Chronic fatigue syndrome	0(0%)
Fibromyalgia	0(0%)
Temporomandibular joint disorder	1(0.3%)
Migraine or tension headaches	6(1.9%)
Irritable bowel syndrome	4(1.3%)
Multiple chemical sensitivities	0(0%)
Neck injury (including whiplash)	5(1.6%)
Anxiety or panic attacks	10(3.2%)
Depression	29(9.4%)

Abbreviations: CSI-CV Chinese Version of the Central Sensitization Inventory.

Table 4 Cronbach's α and Intraclass Correlation Coefficients of Test–Retest Reliability

Item	Questions	Cronbach's α	ICC
Sum	Total score	0.910	0.924
F1	Physical Symptoms	0.807	0.838
F2	Emotional Distress	0.849	0.873
F3	Fatigue and Sleep Problems	0.817	0.848
F4	Headache and Jaw Symptoms	0.800	0.833
F5	Urological Symptoms	0.758	0.807

Abbreviations: ICC Intraclass Correlation Coefficients.

from 0.758 to 0.849, indicating acceptable levels of internal consistency across these dimensions. The ICC was 0.924, while the SEM was calculated to be 2.92.

Structural Validity

The results of the KMO test indicated a value of 0.836, while Bartlett's test of sphericity yielded a significance level of $P < 0.001$, demonstrating the dataset's suitability for factor analysis. Utilizing exploratory factor analysis (EFA) and the scree plot (refer to Figure 1), we identified a five-factor model. The eigenvalues for these factors were 8.20, 2.11, 1.80, 1.55, and 1.38, which corresponded to variance contributions of 32.88%, 8.46%, 7.2%, 6.19%, and 5.52%, respectively, leading to a cumulative explained variance of 60.24%. The factor loading matrix is presented in Table 2.

Specifically, Factor 1, termed "Physical Symptoms", encompasses items 2, 6, 9, 14, 18, 20, and 25. Factor 2, labeled "Emotional Symptoms", consists of items 3, 13, 15, 16, 17, 23, and 24. Factor 3, associated with fatigue and sleep disturbances, is designated "Fatigue and Sleep Problems", including items 1, 8, 12, and 22. Factor 4, referred to as "Headache and Jaw Pain Symptoms", comprises items 4, 5, 7, 10, and 19. Finally, Factor 5, identified as "Urological Problems", includes items 11 and 21. The identification of these factors enhances our understanding of the underlying data structure, facilitating further research and application.

Criterion Validity

Table 5 presents the correlation analysis between scores from CSI-CV and the BPI, Oswestry ODI, and EQ-5D-5L. The results indicate a significant positive correlation between CSI-CV scores and BPI scores ($r = 0.586$, $p < 0.001$) as well as ODI scores ($r = 0.416$, $p < 0.001$). In contrast, CSI-CV scores demonstrated a significant negative correlation with EQ-5D-5L scores ($r = -0.515$, $p < 0.001$) and the EQ Visual Analogue Scale (EQ-VAS) ($r = -0.667$, $p < 0.001$).

Feasibility

All participants successfully completed the CSI-CV questionnaire, with no omissions or duplicate responses found in Part A. However, a few participants encountered challenges while completing Part B of the CSI-CV. These difficulties primarily stemmed from a lack of understanding of specific diagnostic terminology, which required clarification and guidance from clinicians and experts to ensure accurate responses.

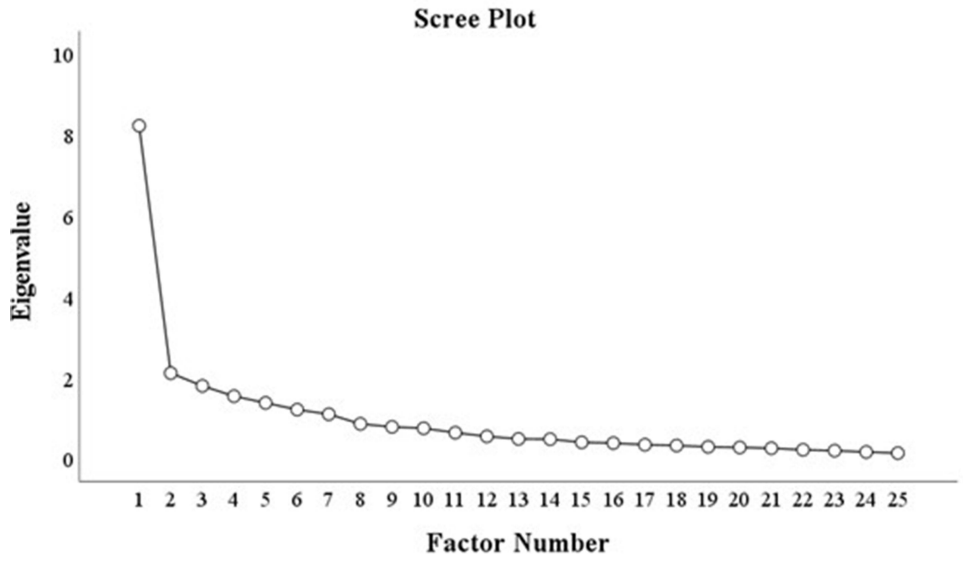

Figure 1 Scree plot of exploratory factor analysis.

Table 5 Results of Correlations Between CSI-CV and Related Scales

Variance	Mean (SD)	Correlation coefficient	P value	Cronbach's α
BPI	40.1(19.5)	0.586	<0.001	0.899
ODI	15.7(7.8)	0.416	<0.001	0.922
EQ-5D-5L	0.49(0.27)	−0.515	<0.001	0.871
EQ-VAS	59.2(17.2)	−0.667	<0.001	
CSI-CV	37.5(10.6)			

Abbreviations: BPI Brief Pain Inventory; ODI Oswestry Disability Index; EQ-5D-5L and EQ-VAS Five-Level EuroQol Five-Dimensional Questionnaire.

Table 6 CSI-CV Scores in Different Populations

Factor		N	Total score of CSI	P value
Age	≥ 70 years old	43	37.98±11.08	0.711
	< 70 years old	267	37.42±10.53	
Gender	Male	106	35.71±10.05[a]	0.037
	Female	204	38.43±10.77[a]	
Employment status	In work	176	38.94±11.34[a]	0.016
	Retired	111	35.51±9.30[a]	
	Be unemployed	23	36.09±9.04	
Marital status	Married	256	37.59±10.55	0.497
	Unmarried	12	34.92±12.19	
	Missing	42	37.67±10.60	
Education	Primary school or below	152	37.68±9.78	0.513
	Middle	42	35.26±10.8	
	High	61	37.92±11.59	
	University or above	55	38.24±11.51	

Notes: Values are expressed as means ± standard deviation. [a]Items with significant differences. P value represents the comparison result of T-tests or ANOVA with Bonferroni correction.

Discriminant Validity

The analysis of CSI-CV scores across various demographic groups is summarized in Table 6. No statistically significant differences were observed in total CSI-CV scores when comparing participants across different age groups, educational levels, or marital statuses. However, notable differences were identified based on gender and employment status. Specifically, female participants exhibited significantly higher CSI-CV scores (38.43 ± 10.77) compared to their male counterparts (35.71 ± 10.05). Additionally, employed individuals demonstrated markedly higher scores (38.94 ± 11.34) than retirees (35.51 ± 9.30) and unemployed participants (36.09 ± 9.04).

Discussion

CS represents a critical characteristic of chronic pain conditions, reflecting alterations in the central nervous system's processing of pain signals. This results in an increased perception of pain and lowered pain thresholds.[62] Emerging evidence increasingly suggests a strong association between CLBP and CS. Notably, CS serves as a key mechanism underlying the persistence and worsening of pain in patients with CLBP, emphasizing the significance of central nervous system alterations alongside local spinal pathologies.[63,64] Standard treatment approaches often show reduced efficacy in individuals with CLBP who also exhibit CS.[65] As a response, the CSI was developed to effectively identify symptoms related to CS and CSS, facilitating the implementation of personalized diagnostic and therapeutic interventions for patients.[62] However, to date, there has been no cross-cultural translation and validation of the CSI specifically tailored for CNSLBP patients in mainland China. Accordingly, the objective of this research is to develop a culturally adapted Chinese version of the CSI scale for the CNSLBP patient group and to evaluate its psychometric characteristics.

In study, EFA identified a five-factor model for the CSI-CV, consistent with the cross-cultural adaptation and validation research on the 2017 Japanese version[40] and the French version.[66] In contrast, this model diverges from the one-factor model reported in the Persian version,[35] as well as the four-factor models established in the English,[50] Polish,[34] and Dutch[12] versions, and the six-factor models in the Korean[67] and the 2021 Japanese versions.[31] The four-dimensional theoretical framework of the CSI, initially proposed by Mayer et al, has gained widespread acceptance in the global research community.[68] Moreover, previous studies have indicated that the CSI may exhibit single-dimensional, five-dimensional, or six-dimensional structures.[69] We attribute the observed discrepancies in factor structures to differences in the conceptualization of the CSI across various linguistic and cultural groups. The five-factor model identified in this study is specifically tailored to the population in Northwest China, highlighting the necessity of adapting the CSI assessment tool to particular cultural contexts. Such adaptation is essential for ensuring both the accuracy and stability of the measurement framework.

The Cronbach's alpha for the CSI-CV was found to be 0.910, indicating a high level of internal consistency. Additionally, the Cronbach's α values for the 25 sub-items ranged from 0.904 to 0.911, demonstrating strong reliability. These values align with those of the English version (Cronbach's α = 0.87),[50] the Polish version (Cronbach's α = 0.933),[34] the Persian version (Cronbach's α = 0.87),[35] the 2017 Japanese version (Cronbach's α = 0.89),[40] the Spanish version (Cronbach's α = 0.872),[70] the Italian version (Cronbach's α = 0.87),[32] and the German version (Cronbach's α = 0.928).[69] These results indicate that the CSI has shown consistent internal stability in different cultural backgrounds.

In this study, the ICC for the CSI-CV was found to be 0.924, indicating excellent reliability. This finding aligns with results from prior versions, including the English version (ICC = 0.817),[50] the 2017 Japanese version (ICC = 0.85),[40] the Spanish version (ICC = 0.91),[70] the Dutch version (ICC = 0.88),[12] and the German version (ICC = 0.917).[69] Additionally, the CSI-CV scale demonstrates significant positive correlations with other measures, such as BPI and the ODI, in terms of pain intensity and interference. Conversely, CSI-CV scores show significant negative correlations with the EQ-5D-5L and EQ-VAS scores, reflecting that higher scores on the EQ-5D-5L and EQ-VAS are associated with better health-related quality of life.[71] These results are consistent with findings from the 2017 Japanese and Korean versions, further supporting the robust psychometric properties of the CSI-CV.

This research not only evaluated the psychometric characteristics of the CSI-CV but also investigated its practical application. The findings revealed that the average time required for participants to complete the CSI-CV questionnaire was 7.8 minutes, with a standard deviation of 1.6 minutes, indicating a relatively quick assessment. Nonetheless, a small proportion of participants encountered difficulties when completing Section B of the CSI-CV, primarily due to a lack of understanding of certain diagnostic terminology. These challenges were readily addressed through explanations and guidance provided by clinicians and experts. In conclusion, the CSI-CV not only proves to be easy to administer but also minimizes the cognitive load on participants, thereby enhancing their willingness to engage with and adhere to the completion of the questionnaire.

In this study, the CSI scores ranged from 14 to 60, with a mean score of 37.5 ± 10.6. This average is higher than those reported in the 2017 Japanese version (21.91 ± 13.31),[40] the 2021 Japanese version (22.6 ± 12.4),[31] the Greek version (29.63 ± 8.62),[72] the Italian version (33.93 ± 11.88),[32] and the Polish version (35.27 ± 17.25),[34] but lower than the scores in the English version (41.6 ± 14.8),[50] the German version (43.6 ± 15.0),[69] and the Serbian version (44.64 ± 80.61).[33] Additionally, 53 patients (17.1%) were diagnosed with conditions associated with CS, which falls within the range of 13% to 56% reported in other studies.[32,73] When examining regional variations in CSI scores and CS diagnostic rates, it is crucial to consider factors such as culture, ethnicity, and healthcare conditions, as these elements influence patients' perceptions and expressions of psychological health issues, subsequently affecting symptom reporting. Most participants in our study were from an underdeveloped inland region in northwest China, where limited healthcare resources and a conservative social culture may discourage open discussions about psychological health. Consequently, while our CS diagnostic rate stands at 17.1%, it is lower compared to countries with more developed healthcare systems, such as the Netherlands[12] and Italy.[32] Furthermore, this investigation exclusively targeted individuals with CNSLBP, diverging from prior studies that encompassed a wider spectrum of pain conditions, such as musculoskeletal pain, fibromyalgia, and post-acute injury pain. This particular patient population may significantly contribute to the observed differences in CSI-CV scores.

Significant differences in total CSI scores were observed among individuals with varying demographic characteristics. Specifically, females had higher CSI scores (38.43 ± 10.77) compared to males (35.71 ± 10.05), consistent with previous

research findings.[74] Furthermore, occupation played a role in CSI scores, with employed individuals scoring significantly higher (38.94 ± 11.34) than retirees (35.51 ± 9.30) and unemployed individuals (36.09 ± 9.04). This difference can be attributed to a greater proportion of long-term heavy laborers and sedentary workers within the employed group, who are at increased risk for back pain and disc herniation.[75] In contrast, while many retirees had a history of CNSLBP, most reported gradual improvement in their symptoms, likely related to reduced work intensity, a more comfortable lifestyle, and improved mood, in line with previous studies.[16,74] Among the CNSLBP population, no significant differences in CSI scores were found based on age, marital status, or education level. Although some studies have identified age as a risk factor for CNSLBP,[76,77] our research indicated that patients over 70 years old had slightly higher CSI scores (37.98 ± 11.08) compared to those under 70 (37.42 ± 10.53), but this difference was not statistically significant. This may be attributed to the fact that recruitment occurred within a single orthopedic department, where older patients with back pain were less common and more likely to be admitted for complex internal conditions. Additionally, older patients in China may be less inclined to openly discuss or address their health and psychological issues due to conservative cultural norms.

Several limitations of this research require consideration. First, the sample was drawn from a single hospital, predominantly reflecting patients from the northwest region of China. Considering the vast geographical variations across the nation, this restriction could influence the applicability of the results to other areas of mainland China. Second, the study did not utilize QST for the direct measurement of CS, which could influence the accuracy of CS diagnoses. Future research should incorporate QST to further validate the effectiveness of the CSI-CV and consider it as a supplementary assessment method. Thirdly, the evaluation of CSS was based on participant-completed surveys, which might have led to subjective response bias. Lastly, the absence of a healthy control group limits the study's ability to evaluate the CSI-CV's effectiveness in distinguishing between patients with CS and those without. Further research is needed to address these gaps.

Conclusions

This study conducted a preliminary and comprehensive evaluation of the psychometric properties of the Simplified Chinese version of the Central Sensitization Inventory (CSI-CV) in patients with chronic non-specific low back pain (CNSLBP). The CSI-CV underwent successful cross-cultural adaptation, and its validity and accuracy were ensured through back-translation, expert discussions, and pilot testing feedback. During the translation process, no issues of ambiguity or inapplicability due to cultural or social differences were identified, thus confirming the cultural appropriateness of the scale. The results indicate that the transition to Simplified Chinese was successful, with all items maintaining strong comparability. The scale demonstrated excellent metrics in reliability, validity, and clarity, with strong internal consistency, a clear factor structure, and high overall stability. These findings support the use of the CSI-CV for assessing central sensitization in Chinese-speaking patients with CNSLBP, aiding clinicians in making more informed and accurate decisions.

Abbreviations

CSI-CV, Chinese Version of the Central Sensitization Inventory; CNSLBP, Chronic non-specific Low Back Pain; CLBP, Chronic Low Back Pain; CS, Central Sensitization; CSS, Central Sensitization Syndrome; QST, Quantitative Sensory Testing; EFA, Exploratory Factor Analysis; ICC, Intraclass Correlation Coefficient; BPI, Brief Pain Inventory; ODI, Oswestry Disability Index; EQ-5D-5L, Five-Level EuroQol Five-Dimensional Questionnaire; ANOVA, One-Way Analysis of Variance; SEM, Standard Error of Measurement; SD, Standard Deviation.

Ethics Approval and Consent to Participate

This research complies with the principles of the Helsinki Declaration and has been granted approval by the Medical Ethics Committee at Honghui Hospital, Xi'an Jiaotong University (approval number: 202209026). Furthermore, all participants have provided their written informed consent.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors affirm that no conflicts of interest are associated with their contributions to this research.

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