DOI: 10.21088/potj.0974.5777.18325.4

Physiotherapy and Occupational Therapy Journal
Volume 18 Number 3, July - September 2025

ORIGINAL ARTICLE

Central Sensitization and its Impact on Disability, Sleep, Depression, and Quality of Life in Chronic Musculoskeletal Pain: A Cross-Sectional Study

Bid Dibyendunarayan Dhrubaprasad[1], Bhuriwala Sakina Karimbhai[2], Panwala Keval Vijaykumar[3], Vachhani Pinalben Dineshbhai[4], Virani Palak Vinodbhai[5]

Bid Dibyendunarayan Dhrubaprasad, Bhuriwala Sakina Karimbhai et. al, Central Sensitization and Its Impact on Disability, Sleep, Depression, and Quality of Life in Chronic Musculoskeletal Pain: A Cross-Sectional Study. Physio. and Occ. Therapy Jr. 2025; 18(3): 211-221.

ABSTRACT

Background: Chronic musculoskeletal pain (CMP) disorders, including fibromyalgia, osteoarthritis, and chronic low back pain, are prevalent conditions that result in substantial disability, psychological distress, and reduced quality of life (QoL). Emerging evidence identifies central sensitization (CS), characterized by heightened responsiveness of the central nervous system to nociceptive stimuli, as a key mechanism in the persistence and amplification of pain. However, the broader biopsychosocial impact of CS in a single integrated framework remains underexplored.

Objectives: This study aimed to investigate the relationship between central sensitization and disability, sleep disturbance, depression, and quality of life in individuals with CMP. Additionally, it assessed whether demographic factors age, sex, and pain duration moderate these relationships.

Methods: A cross-sectional analysis was conducted on 150 participants aged 25–75 years with chronic musculoskeletal pain for ≥3 months. Participants completed the validated Gujarati versions of the Central Sensitization Inventory (CSI-G), Roland-Morris Disability Questionnaire (RMDQ-G), Pittsburgh Sleep Quality Index (PSQI-G), Patient Health Questionnaire-9 (PHQ-9), and Short Form-12 (SF-12) for physical and mental QoL. Correlation and regression analyses were performed using SPSS v20.0, with moderation analyses evaluating the demographic influences.

AUTHOR'S AFFILIATION:

[1] Head of the Department (Musculoskeletal Sciences), The Sarvajanik College of Physiotherapy, Surat, Gujarat, India.
[2] Physiotherapist, Private Practitioner, Surat, Gujarat, India.
[3] Physiotherapist, Private Practitioner, Surat, Gujarat, India
[4] Physiotherapist, Private Practitioner, Surat, Gujarat, India.
[5] Physiotherapist, Private Practitioner, Surat, Gujarat, India.

CORRESPONDING AUTHOR:

Bid Dibyendunarayan Dhrubaprasad, Head of the Department (Musculoskeletal Sciences), The Sarvajanik College of Physiotherapy, Surat, Gujarat, India.

E-mail: dnbid71@gmail.com

➢ **Received:** 19-04-2025 ➢ **Accepted:** 18-06-2025

Results: Twenty percent of the participants exhibited clinically significant CS and were predominantly female. The CSI-G scores were significantly correlated with increased disability (ρ = 0.530), poor sleep quality (ρ = 0.363), higher depression (ρ = 0.656), and reduced QoL (SF-12 PCS: ρ = -0.467; MCS: ρ = -0.406) (all $p < 0.001$). Regression analysis identified depression, disability, sleep quality, pain duration, and sex as the significant predictors of CS. Age moderated the CS–disability link, while longer pain duration intensified the CS–depression association.

Conclusion: Central sensitization is a major contributor to functional, psychological, and quality of life impairments in CMP.These findings emphasize the need for multidimensional personalized interventions targeting central mechanisms, particularly in females and patients with prolonged pain.Routine CS screening and integrated management strategies may improve the outcomes and enhance the overall well-being of the population.

KEYWORDS

• Central Sensitization • Chronic Musculoskeletal Pain • Disability • Depression • Sleep Disturbance • Quality of Life • Cross-Sectional Study

INTRODUCTION

Chronic musculoskeletal pain (CMP) disorders, encompassing conditions such as fibromyalgia, osteoarthritis, chronic low back pain, and rheumatoid arthritis, are a major global public health concern.[1] These conditions contribute substantially to long-term disability, impair physical function, and compromise psychological well-being, culminating in markedly reduced quality of life (QoL).[2] The complex etiology of chronic pain extends beyond localized tissue damage and mechanical dysfunction, increasingly implicating central nervous system mechanisms, most notably **central sensitization (CS)**, as pivotal contributors to pain persistence and amplification.[3]

Central sensitization refers to a pathological state of heightened reactivity within the central nervous system, wherein nociceptive neurons exhibit hyper-responsiveness to both painful and nonpainful stimuli.[4] This maladaptive neuroplasticity not only intensifies pain perception but also alters pain modulation pathways, manifesting clinically as allodynia, hyperalgesia, and widespread pain.[4,5] Recent neurobiological research has identified central sensitization as a core pathophysiological process underlying various chronic pain syndromes; however, its broader impact on biopsychosocial outcomes, such as physical disability, sleep disturbance, depression, and QoL, remains insufficiently characterized within an integrated analytical framework.[6,7]

Emerging evidence suggests that CS is not an isolated sensory phenomenon but is intricately linked to systemic disruptions in physical and mental health.[8] Patients exhibiting central sensitization commonly report functional limitations and activity restrictions driven by increased pain intensity and pain related fear avoidance.[9] Furthermore, poor sleep quality is a prevalent concern in CMP populations, with studies reporting that over 70% of patients experience significant disturbances in sleep architecture, which in turn exacerbates pain sensitivity and emotional dysregulation. The bidirectional interplay between sleep and pain further reinforces central sensitization, suggesting a vicious cycle that perpetuates patients' suffering.[10-12]

Depression is a frequent and often under-recognized comorbidity among individuals with chronic pain.[13] Shared neural substrates, including serotonergic and noradrenergic dysregulation, as well as overlapping functional activation in limbic brain regions, highlight the convergence of pain and mood disorders.[14,15] Central sensitization may serve as a mechanistic bridge linking chronic pain and affective disturbances, thereby intensifying pain perception and emotional distress.[16] These relationships contribute to significantly impaired health-related quality of life and affect both the physical and mental dimensions of well-being.

Despite growing recognition of CS as a critical determinant of chronic pain experience,

few studies have concurrently examined its influence across the spectrum of disability, sleep, depression, and QoL in a single, well-characterized population. Moreover, the potential moderating effects of demographic variables such as age, sex, and duration of pain on the central sensitization-outcome relationship remain underexplored.

This study sought to address these gaps using a cross-sectional design to comprehensively evaluate the impact of central sensitization on disability, sleep disturbance, depressive symptoms, and quality of life among individuals with chronic musculoskeletal pain disorders. By integrating validated psychometric tools and statistical modeling, the present research aimed to elucidate the multidimensional burden of CS and identify patient subgroups at heightened risk, thereby informing personalized and mechanism-driven approaches to chronic pain management.

MATERIALS AND METHODS

Study Design and Setting

This research used a cross-sectional observational study aimed to investigate the association between central sensitization (CS) and its effects on disability, sleep disturbance, depression, and quality of life (QoL) in individuals with chronic musculoskeletal pain (CMP). The study was conducted over a period of four months, from December 2024 to March 2025, across various physiotherapy clinics in Surat, Gujarat.

Participants

A total of 150 participants, aged between 25 and 75 years, were recruited using purposive sampling. Eligible participants included individuals clinically diagnosed with CMP conditions persisting for more than three months, specifically those with fibromyalgia, osteoarthritis, chronic low back pain, neck pain, or rheumatoid arthritis. All participants were required to be literate in Gujarati to ensure valid and reliable responses to the study questionnaires, which were administered as validated Gujarati translations.

Inclusion Criteria

- Adults aged 25–75 years.
- Diagnosis of CMP conditions such as fibromyalgia, osteoarthritis, chronic low back pain, neck pain, or rheumatoid arthritis.
- Duration of musculoskeletal pain ≥3 months.
- Willingness and ability to provide informed consent.
- Ability to comprehend and respond to questionnaires in Gujarati.

Exclusion Criteria

- History of neurological disorders (e.g., stroke and Parkinson's disease).
- Active malignancy.
- Significant cognitive impairment or psychiatric illness impedes participation.
- Recent musculoskeletal surgery (<12 months).
- Pregnant women.

Sample Size Calculation

A priori power analysis was performed using the G*Power software for multiple regression analysis. Assuming a moderate effect size ($f^2 = 0.15$), alpha level of 0.05, and power of 0.80, the minimum required sample size was estimated to be 92. To improve the robustness and generalizability of the findings, a final sample of 150 participants was recruited.

Data Collection Procedure

The participants were recruited from outpatient departments and community physiotherapy clinics. After obtaining written informed consent, data were collected in a single session lasting approximately 25–30 minutes. Trained physiotherapy researchers administered the study tools and provided assistance when necessary to ensure accurate responses. All responses were anonymized and stored securely to ensure confidentiality.

Outcome Measures

Validated and culturally adapted instruments were used to assess central sensitization, disability, sleep quality, depressive symptoms, and QoL.

1. Central Sensitization Inventory–Gujarati (CSI-G)

The CSI-G is a 25-item self-report questionnaire that assesses the symptoms associated with central sensitization. Each

item is scored on a 5-point Likert scale (0–4), yielding a total score ranging from 0 to 100. A score ≥40 indicates clinically significant central sensitization.[17]

2. Roland-Morris Disability Questionnaire–Gujarati (RMDQ-G)

This 24-item instrument evaluates the degree of physical disability resulting from musculoskeletal pain. Higher scores reflect greater disability.[18]

3. Pittsburgh Sleep Quality Index–Gujarati (PSQI-G)

The PSQI-G is a 19-item questionnaire that assesses subjective sleep quality in the previous month.Global scores of >5 indicated poor sleep quality.[19]

4. Patient Health Questionnaire-9–Gujarati (PHQ-9-G)

The PHQ-9-G evaluates depressive symptoms experienced in the last two weeks. The total scores range from 0 to 27 and categorize depression severity as minimal, mild, moderate, moderately severe, or severe.[20]

5. Short Form-12 Health Survey–Gujarati (SF-12-G)

The SF-12-G assesses health-related QoL using two composite scores: Physical Component Summary (PCS) and Mental Component Summary (MCS).Lower scores indicate poorer QoL.[21]

Data Analysis

All analyses were conducted using SPSS 20.0, IBM, Armonk, NY, USA, with 95% confidence interval (CI) limits and a p-value <0.05, which was considered statistically significant. Descriptive statistics were computed for the demographic and clinical variables. Normality was tested using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Owing to deviations from normality for several variables, Spearman's rank correlation was used for bivariate analyses.

Moderation analyses were conducted using interaction terms to assess whether demographic variables (age, sex, and pain duration) modified the relationship between central sensitization and outcome variables. Multiple linear regression models were constructed to identify the predictors of CSI scores after adjusting for potential confounders.

RESULTS

Demographic and Clinical Characteristics

A total of 150 participants (60 males, 90 females) aged between 25 and 75 years (mean = 45.76, SD = 11.03) were included in the analysis.Descriptive data for the study variables are presented in Table 1.

Table 1: Demographic and Health Characteristics (N = 150)

Variable	Minimum	Maximum	Mean	SD
Age (years)	25.0	75.0	45.76	11.03
Height (cm)	129	185	160.63	9.16
Weight (kg)	40	86	64.18	8.90
BMI	17.0	38.0	25.04	4.07
Pain Duration (months)	3.0	48.0	9.28	6.24
CSI-G Total	7.0	68.0	27.99	13.35
SF-12 PCS	19.78	58.74	39.37	7.69
SF-12 MCS	24.17	62.75	42.61	8.09
PSQI-G Total	2.0	37.0	10.47	6.32
PHQ-9 Total	0.0	22.0	5.92	4.11
RMDQ-G Total	0.0	24.0	9.72	5.57

The study sample was stratified into three age categories: Young Adults (25–40 years, n = 51), Middle-Aged Adults (41–55 years, n = 69), and Older Adults (56–75 years, n = 30). The gender distribution within each category revealed a consistently higher proportion of females across all age groups, particularly in the middle-aged cohort.

Prevalence of Central Sensitization and Clinical Outcomes

The Central Sensitization Inventory (CSI-G) scores were used to classify participants into two categories: those without central sensitization (CSI-G score <40) and those with central sensitization (CSI-G score ≥40). Of the 150 participants, 120 (80%) fell below the clinical threshold for central sensitization, whereas 30 (20%) met the criteria for significant CS. In the CS group, 90% were female, indicating a sex-related predisposition.

Disability (RMDQ-G)

Disability levels were assessed using the Roland-Morris Disability questionnaire (RMDQ-G). Among all participants, 26 (17.3%) reported minimal disability (scores 0–4), 96 (64%) reported mild disability (scores 5–14), and 28 (18.7%) reported moderate-to-severe disability (scores 15–24). Notably, a higher proportion of females (n = 21) reported moderate to severe disability compared to

males (n = 7), suggesting a gender-linked disparity in disability burden.

Sleep Quality (PSQI-G)

Sleep quality, measured using the PSQI-G, showed that 116 participants (77.3%) had poor sleep quality (global scores >5), whereas only 34 (22.7%) reported good sleep. Gender analysis revealed that 71 out of 90 females (78.9%) and 45 out of 60 males (75%) reported poor sleep, reinforcing the high prevalence of sleep disturbances in CMP populations.

Depression (PHQ-9-G)

The severity of depressive symptoms was classified using PHQ-9-G scores: minimal (n = 62), mild (n = 66), moderate (n = 15), moderately severe (n = 5), and severe (n = 2).Female participants displayed higher rates of mild to severe depression (n = 62) than male participants (n = 26). Only females were represented in the severe depression category.

Quality of Life (SF-12-G)

Quality of life was measured using the SF-12 Physical Component Score (PCS) and the Mental Component Score (MCS). A total of 137 participants (91.3%) had below-average physical QoL, with only 13 (8.7%) scoring above average. Similarly, 119 participants (79.3%) exhibited a below-average mental health status.Females consistently reported poorer outcomes in both the physical and mental QoL domains.

Correlation Analyses

Spearman's rank correlation coefficients were calculated to assess the relationship between CSI-G scores and other outcome variables.

- **CSI-G and RMDQ-G (disability):** A strong positive correlation was found ($\rho = 0.530$, $p < 0.001$), indicating that higher central sensitization is associated with increased disability.
- **CSI-G and PSQI-G (Sleep Quality):** A moderate positive correlation was observed ($\rho = 0.363$, $p < 0.001$), suggesting that central sensitization is linked to poor sleep quality.
- **CSI-G and PHQ-9 (depression)** A strong positive correlation was found ($\rho = 0.656$, $p < 0.001$), indicating a robust association between higher CSI-G scores and more severe depressive symptoms.
- **CSI-G and SF-12 PCS (Physical QoL):** A moderate negative correlation was observed ($\rho = -0.467$, $p < 0.001$), showing that central sensitization adversely affects physical QoL.
- **CSI-G and SF-12 MCS (Mental QoL):** A moderate negative correlation was also observed with mental health QoL ($\rho = -0.406$, $p < 0.001$).

Table 2: Spearman's Correlations Between CSI-G and Outcomes

Variables	ρ (rho)	p-value
CSI-G vs. PSQI-G (Sleep)	0.363**	<0.001
CSI-G vs. RMDQ-G (Disability)	0.530**	<0.001
CSI-G vs. PHQ-9 (Depression)	0.656**	<0.001
CSI-G vs. SF-12 PCS	-0.467**	<0.001
CSI-G vs. SF-12 MCS	-0.406**	<0.001

• Note:p < 0.01, two-tailed.

These findings underscore the multidimensional impact of central sensitization across physical, psychological, and quality-of-life domains.

Moderation Analysis

Moderation effects were explored to determine whether demographic factors influenced the relationship between CS and outcome variables.

Table 3: Moderation Effects of Demographics on CS–Outcome Relationships

Outcome	Moderator	Interaction p-value	Interpretation
RMDQ-G Total	Age	0.03*	Stronger CS-disability effect in older adults
PSQI-G Score	Gender	0.21	No significant gender moderation
PHQ-9 Total	Pain Duration	0.01*	Longer pain duration strengthens CS-depression link

- **Age × CS → disability (RMDQ-G):** A statistically significant interaction (p = 0.03) indicated that age moderated the relationship between CS and disability. Older individuals exhibited a stronger correlation between CS and functional limitation.
- **Gender × CS → Sleep Quality (PSQI-G):** No significant moderation was observed (p = 0.21), suggesting that sex did not significantly influence the relationship between CS and sleep disturbance.
- **Pain Duration × CS → Depression (PHQ-9)** A significant interaction (p =

0.01) revealed that a longer duration of pain intensified the impact of CS on depressive symptoms.

Regression Analysis

A multiple linear regression model was used to identify the significant predictors of central sensitization (CSI-G total score). The model explained 45% of the variance in CSI-G scores (Adjusted $R^2 = 0.42$, $F(6, 93) = 12.7$, $p < 0.001$).

Table 4: Multiple Linear Regression Predicting Central Sensitization (CSI-G)

Predictor	B	β (Standardized)	p-value	VIF
Age	-0.05	-0.12	0.08	1.21
Gender (Female)	2.10	0.15	0.02*	1.05
Pain Duration	0.30	0.25	0.001**	1.30
PHQ-9 Total	0.45	0.32	<0.001**	1.42
RMDQ-G Total	0.60	0.40	<0.001**	1.50
PSQI-G Total	0.20	0.18	0.01*	1.25

Model Summary: $R^2 = 0.45$, Adjusted $R^2 = 0.42$, $F(6,93) = 12.7$, $p < 0.001$
Note: *$p < 0.05$, **$p < 0.01$

Significant Predictors:

Depression (PHQ-9 Total): $\beta = 0.32$, $p < 0.001$

Disability (RMDQ Total): $\beta = 0.40$, $p < 0.001$

Sleep Quality (PSQI Global Score): $\beta = 0.18$, $p = 0.01$

Pain Duration: $\beta = 0.25$, $p = 0.001$

Gender (Female): $\beta = 0.15$, $p = 0.02$

Age was not a significant predictor ($\beta = -0.12$, $p = 0.08$). All variance inflation factor (VIF) values were <1.5, indicating no multicollinearity issues. The model supports the hypothesis that psychological and functional factors (depression, disability, and sleep disturbance), along with chronicity of pain and female sex, significantly predict central sensitization in patients with CMP.

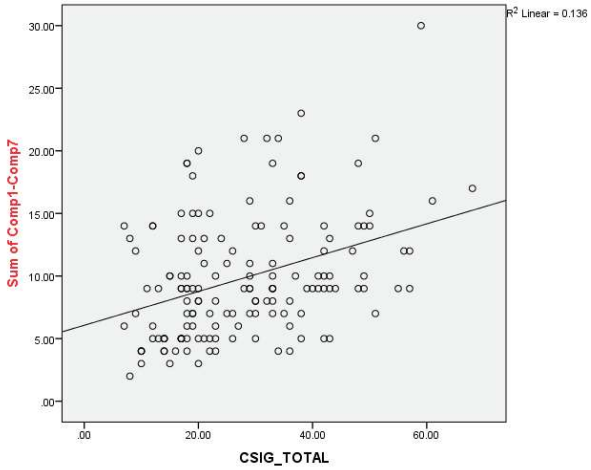
Key Findings of Regression Analysis

Central sensitization was significantly and positively correlated with disability, depression, and poor sleep.

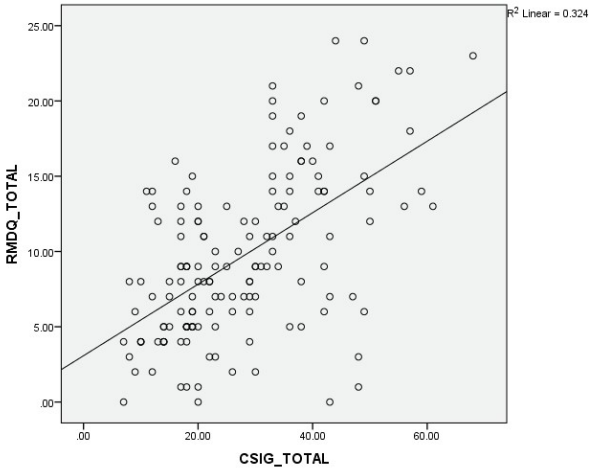
It negatively correlates with both the physical and mental aspects of quality of life.

Regression and moderation analyses highlighted female sex, longer pain duration, and depressive symptoms as significant predictors or amplifiers of the effects of CS.

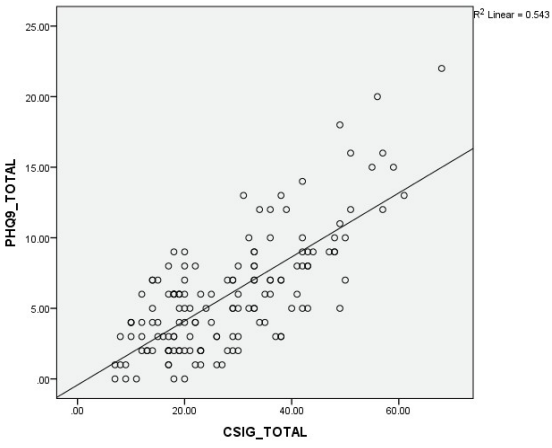
Age moderates the CS–disability relationship; older patients are more affected.



Graph 1: Scatter Plot of CSI-G vs. PISQI Global Score

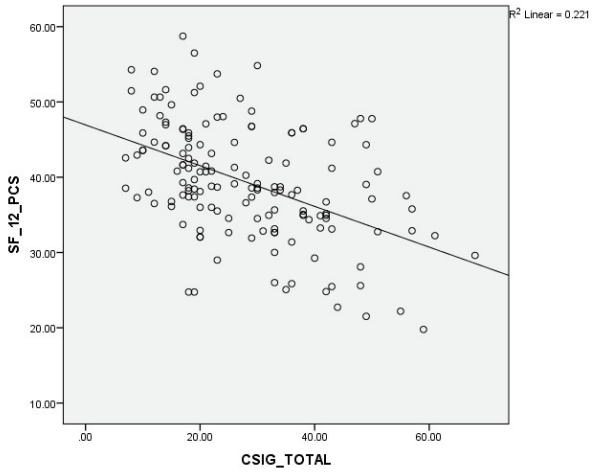


Graph 2: Scatter Plot of CSI-G vs. RMDQ-G Scores

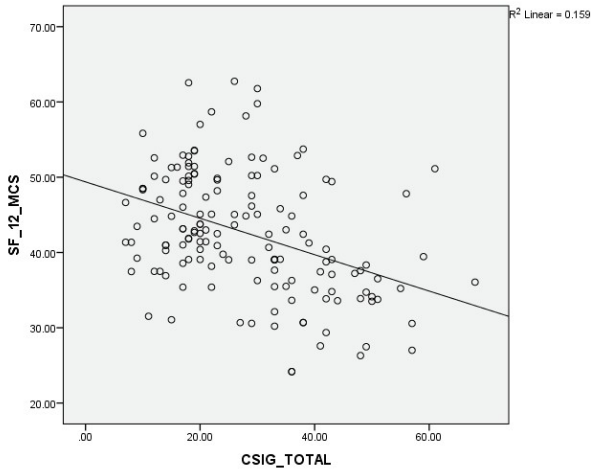


Graph 3: Scatter Plot of CSI-G vs. PHQ-9-G (Depression)

CSI-G vs. PISQI-G, RMDQ-G, and PHQ-9: Upward trends confirmed strong positive correlations among central sensitization, disability, and depression.



Graph 4: Scatter Plot of CSI-G vs. SF-12 PCS



Graph 5: Scatter Plot of CSI-G vs. SF-12 MCS

CSI-G vs. SF-12 PCS/MCS: Downward trends confirmed the negative association between CS and QoL.

DISCUSSION

This study investigated the impact of central sensitization (CS) on disability, sleep disturbance, depression, and quality of life (QoL) in individuals with chronic musculoskeletal pain (CMP) disorders.The results provide strong evidence supporting the hypothesis that CS is a critical mediator of poor biopsychosocial outcomes in CMP patients. Importantly, the findings also highlight those demographic factors, particularly age, sex, and duration of pain, modulate the expression and consequences of CS, suggesting the need for more individualized, mechanism-driven interventions.

Central Sensitization and Its Prevalence

Approximately 20% of the participants in this sample met the threshold for clinically significant central sensitization, with a notably higher prevalence among females. This sex disparity aligns with previous research suggesting that women may be more vulnerable to central pain amplification due to hormonal differences, greater pain sensitivity, and distinct patterns of central nervous system processing.[22] Studies have identified estrogen as a potential modulator of nociceptive pathways, which could partly explain the heightened central pain response in females.[23,24] Additionally, societal and psychological factors, such as pain catastrophizing and higher rates of depression, may contribute to gender differences in CS expression.[25,26]

CS and Disability

One of the most robust findings of this study is the positive correlation between CS and physical disability. Participants with higher CSI-G scores also reported significantly greater functional limitations as measured by the Roland–Morris Disability Questionnaire (RMDQ-G). These results support the existing literature, which describes CS as a driver of widespread hyperalgesia, fear-avoidance behaviors, and activity limitations.[27] Enhanced central nervous system excitability in CS likely contributes to movement-related pain and perceived exertion, leading to functional deconditioning and reduced participation in physical and social activities.[28-30]

Moreover, the moderation analysis revealed that the relationship between CS and disability was more pronounced in older adults. Age-related changes in pain modulation, such as diminished endogenous inhibitory control and increased systemic inflammation, may exacerbate the functional effects of CS. These findings emphasize the importance of early identification and tailored rehabilitation strategies to mitigate the disabling consequences of CS in older patients with CMP.

CS and Sleep Disturbance

Sleep disturbance was highly prevalent in this cohort, with over 77% of the participants

reporting poor sleep quality. A moderate but significant correlation between CS and sleep quality supports a growing body of evidence that points to a bidirectional relationship between pain and sleep dysfunction.[10,31-33] The neurobiological basis for this relationship includes increased nighttime sympathetic activity, alterations in sleep architecture, and reduced activation of the descending pain inhibitory pathways during non-REM sleep.[34,35]

CS may contribute to fragmented sleep by increasing sensitivity to peripheral inputs and promoting a state of hyperarousal.[31,32,36,37] Conversely, chronic sleep disturbance enhances central pain processing by increasing glial activation and impairing pain inhibition.[38] These insights underscore the necessity of integrating sleep assessment and management into chronic pain treatment, particularly in patients presenting with CS features.

CS and Depression

This study also revealed a strong association between central sensitization and depressive symptoms. Participants with higher CSI-G scores exhibited significantly greater depression severity as measured by the PHQ-9. This finding echoes the literature[39,40] describing shared neurochemical and neuroanatomical pathways between chronic pain and depression. Dysregulation of monoaminergic systems (serotonin, dopamine, and norepinephrine) and hyperactivity in the hypothalamic-pituitary-adrenal (HPA) axis are implicated in both conditions.[41,42]

Furthermore, cognitive-emotional factors, such as rumination, helplessness, and pain catastrophizing, which are common in depressive disorders, may amplify pain perception through top-down modulation, fueling the cycle of pain and emotional distress.[43,44] Notably, a longer pain duration significantly moderated the relationship between CS and depression, suggesting that the chronicity of pain experience may sensitize both physical and emotional processing pathways.[45,46]

CS and Quality of Life

Central sensitization was inversely correlated with both physical and mental health components of QoL (SF-12). These findings reflect the wide-ranging impact of CS, extending beyond pain, to affect sleep, emotional regulation, social engagement, and overall life satisfaction. Individuals with higher CS levels often experience persistent discomfort, fatigue, and psychological distress, all of which can undermine their personal and professional functioning.

Our results align with previous studies reporting that CS, more than pain intensity alone, predicts poor QoL in conditions such as fibromyalgia, chronic low back pain, and osteoarthritis.[42,47-49] This suggests that traditional pain-centered models may be insufficient, and that CS should be considered a key treatment target when aiming to improve holistic health outcomes.

Moderating Effects of Demographics

The role of demographic moderators offers additional insights into CS-outcome relationships. Age was found to moderate the link between CS and disability, while the duration of pain moderated the CS-depression association. These interactions highlight the complex and individualized nature of central sensitization.

Interestingly, sex did not significantly moderate the CS-sleep relationship in this study, despite the higher prevalence of CS in females. This suggests that sleep disruption may be a universal consequence of CS across sexes and supports the development of gender-neutral sleep interventions for patients with chronic pain.

Predictors of Central Sensitization

Regression analysis identified depression, disability, poor sleep, pain duration, and female gender as significant predictors of higher CSI-G scores. Together, these variables explained 45% of the variance in central sensitization. Notably, age was not a significant predictor, suggesting that the effects of aging on CS may be more nuanced or mediated through other factors such as comorbid conditions or pain chronicity.

These findings reinforce the biopsychosocial model of chronic pain and suggest that addressing physical symptoms alone is insufficient. The effective management of CS requires a multidimensional approach that considers emotional, cognitive, and behavioral contributors.

CLINICAL IMPLICATIONS

This study has key clinical implications. Routine use of tools such as the Central Sensitization Inventory (CSI) during assessments can help identify patients at risk of poor outcomes and inform treatment priorities. Multimodal approaches, combining physiotherapy, cognitive-behavioral therapy, and sleep strategies, are more effective than isolated treatments, especially when addressing pain, mood, and function together. Personalizing care based on factors such as age and pain duration can further improve outcomes by accounting for variations in central sensitization. Finally, educating patients about pain neurobiology can reduce fear, build self-efficacy, and enhance their engagement in therapy.

STRENGTHS AND LIMITATIONS

The strengths of this study include its well-powered sample, validated Gujarati instruments, and robust statistical analyses. This cross-sectional design enabled the examination of multiple related outcomes. However, it limits causal inference; longitudinal studies are needed to explore the links between CS and function. Self-reported data may involve bias; future research should use objective tools such as sensory testing or neuroimaging.

Future Directions

Future research should focus on longitudinal studies to clarify causal links and track central sensitization (CS) progression. Trials are needed to evaluate targeted treatments, such as pain neuroscience education, CBT, graded motor imagery, and central pain medications. Subgroup analyses should explore how socioeconomic status, culture, and comorbidities impact CS and outcomes. Digital tools, such as remote monitoring, virtual CBT, and biofeedback, can support real-time symptom management.

CONCLUSION

This study identified central sensitization as a key contributor to disability, sleep disturbance, depression, and poor quality of life in patients with chronic musculoskeletal pain.Female sex, longer pain duration, and depression predicted higher sensitization. The findings support a biopsychosocial approach with targeted care through screening, personalization, and teamwork.

Conflict of Interest: None

Funding: Self-financed

REFERENCES

1. Roldán-Jiménez C, Pérez-Cruzado D, Neblett R, Gatchel R, Cuesta-Vargas A. Central Sensitization in Chronic Musculoskeletal Pain Disorders in Different Populations: A Cross-Sectional Study. Pain medicine. 2020.
2. Yücel F, Toprak CS. Central sensitization-related symptoms and their relationship to disability in prevalent chronic musculoskeletal pain: A cross-sectional study. Musculoskeletal science & practice. 2024;73:103147.
3. Nijs J, George S, Clauw D, Fernández de las Peñas C, Kosek E, Ickmans K, et al. Central sensitisation in chronic pain conditions: latest discoveries and their potential for precision medicine. The Lancet Rheumatology. 2021;3 5.
4. Latremoliere A, Woolf CJ. Central Sensitization: A Generator of Pain Hypersensitivity by Central Neural Plasticity. The Journal of Pain. 2009;10(9):895-926.
5. Mayer TG, Neblett R, Cohen H, Howard KJ, Choi YH, Williams MJ, et al. The Development and Psychometric Validation of the Central Sensitization Inventory. Pain Practice. 2012;12(4):276-85.
6. Meeus M, Nijs J. Central sensitization: a biopsychosocial explanation for chronic widespread pain in patients with fibromyalgia and chronic fatigue syndrome. Clinical Rheumatology. 2006;26:465-73.
7. Dionísio GH, Salermo VY, Padilha A. Central sensitization and beliefs among patients with chronic pain in a primary health care unit. Brazilian Journal Of Pain. 2020.
8. Takeuchi T, Hashimoto K, Koyama A, Asakura K, Hashizume M. The Association of Central Sensitisation with Depression, Anxiety, and Somatic Symptoms: A Cross-Sectional Study of a Mental Health Outpatient Clinic in Japan. Life. 2024;14.
9. Werneke M, Hart D, George S, Stratford P, Matheson J, Reyes A. Clinical outcomes for patients classified by fear-avoidance beliefs and centralization phenomenon. Archives of physical medicine and rehabilitation. 2009;90 5:768-77.

10. Abeler K, Bergvik S, Sand T, Friborg O. Daily associations between sleep and pain in patients with chronic musculoskeletal pain. Journal of Sleep Research. 2021;30.
11. Huber F, Toledo T, Newsom G, Rhudy J. The relationship between sleep quality and emotional modulation of spinal, supraspinal, and perceptual measures of pain. Biological Psychology. 2022;171.
12. Friedman A, Regan K. A Deep Dive into the Relationship between Sleep Deprivation and Pain Perception: A Cross-Population Analysis. Research Posters. 2024.
13. Miller L, Caño A. Comorbid chronic pain and depression: who is at risk? The journal of pain : official journal of the American Pain Society. 2009;10 6:619-27.
14. Hooten W. Chronic Pain and Mental Health Disorders: Shared Neural Mechanisms, Epidemiology, and Treatment. Mayo Clinic proceedings. 2016;91 7:955-70.
15. Maallo A, Moulton E, Sieberg C, Giddon D, Borsook D, Holmes S. A lateralized model of the pain-depression dyad. Neuroscience & Biobehavioral Reviews. 2021;127:876-83.
16. Latremoliere A, Woolf C. Central sensitization: a generator of pain hypersensitivity by central neural plasticity. The journal of pain: official journal of the American Pain Society. 2009;10 9:895-926.
17. Bid D, Neela S, Rathod P, Ramalingam T. Content Validity and Test-Retest Reliability of the Gujarati Version of the Central Sensitization Inventory. NJIRM. 2016;7:18-24.
18. Nambi G. Reliability, validity, sensitivity and specificity of Guajarati version of the Roland-Morris Disability Questionnaire. Journal of back and musculoskeletal rehabilitation. 2013;26:149-53.
19. Nariya D, Subhash K. Reliability and Validity of Gujarati Pittsburgh Sleep Quality Index: A Cross-sectional Study. Journal of Clinical and Diagnostic Research. 2021;15:YC04-YC7.
20. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. Journal of general internal medicine. 2001;16(9):606-13.
21. Bais M, Thakrar G. Reliability and Validity of Gujarati Version of SF-12 in Geriatrics. International Journal of Science and Research (IJSR). 2022;11(1).
22. Guekos A, Saxer J, Gallegos DS, Schweinhardt P. Differences in central sensitisation between healthy men and women in Switzerland: a single-centre trial. The Lancet Rheumatology. 2022.
23. Barcelon E, Chung S, Lee J, Lee SJ. Sexual Dimorphism in the Mechanism of Pain Central Sensitization. Cells. 2023;12.
24. Ross J, Queme L, Lamb J, Green K, Jankowski M. Sex differences in primary muscle afferent sensitization following ischemia and reperfusion injury. Biology of Sex Differences. 2018;9.
25. Unruh A. Gender variations in clinical pain experience. Pain. 1996;65:123-67.
26. Michael C, Barrett A. Gender Differences in Pain: Examining Explanations for the Association. Innovation in Aging. 2021;5:887-8.
27. Goldoni ES, Bittencourt J, Santo LRDE, De Souza EB, De Faria JLR, De Andrade Alexandre DJ, et al. Neuropathic-like symptoms and central sensitization related signs and symptoms negatively affect the functional performance of patients with knee osteoarthritis–a cross-sectional study. Osteoarthritis and Cartilage Open. 2023;5.
28. Verbunt J, Seelen H, Vlaeyen J, Heijden G, Heuts P, Pons K, et al. Disuse and deconditioning in chronic low back pain: concepts and hypotheses on contributing mechanisms. European Journal of Pain. 2003;7.
29. Crombez G, Vervaet L, Lysens R, Baeyens F, Eelen P. Avoidance and Confrontation of Painful, Back-Straining Movements in Chronic Back Pain Patients. Behavior Modification. 1998;22:62-77.
30. Vandael K, Vervliet B, Peters M, Meulders A. Excessive generalization of pain-related avoidance behavior: mechanisms, targets for intervention, and future directions. Pain. 2023;164:2405-10.
31. Sachau J, Kersebaum D, Hüllemann P, Adolf D, Kabelitz M, Keller T, et al. The association of self-reported symptoms of central sensitization and sleep disturbances in neuropathic pain. Pain Reports. 2023;8.
32. Bento APDS, Filho N, Ferreira A, Cassetta AP, De Almeida RS. Sleep quality and polysomnographic changes in patients with chronic pain with and without central sensitization signs. Brazilian journal of physical therapy. 2023;27 3:100504.
33. Aoyagi K, He J, Clauw D, Sharma N. Sleep quality in individuals with chronic low back pain and central sensitization. Physiotherapy

research international: the journal for researchers and clinicians in physical therapy. 2022.

34. Karimi R, Mallah N, Scherer R, Rodríguez-Cano R, Takkouche B. Sleep quality as a mediator of the relation between depression and chronic pain: a systematic review and meta-analysis. British journal of anaesthesia. 2023.

35. Sun Y, Laksono I, Selvanathan J, Saripella A, Nagappa M, Pham C, et al. Prevalence of sleep disturbances in patients with chronic non-cancer pain: A systematic review and meta-analysis. Sleep medicine reviews. 2021;57:101467.

36. Reid M, Hamilton K, Nilsson S, Owens M, Phillips J, Finan P, et al. Elevated pain sensitivity is associated with reduced REM sleep in females with comorbid temporomandibular disorder and insomnia. Pain medicine. 2024.

37. Williams D. Phenotypic Features of Central Sensitization. Journal of applied biobehavioral research. 2018;23 2.

38. Haack M, Engert L, Besedovsky L, Goldstein M, Devine J, Dang R, et al. Alterations of pain pathways by experimental sleep disturbances in humans: Central pain-inhibitory, cyclooxygenase, and endocannabinoid pathways. Sleep. 2023.

39. Tafet G, Bernardini R. Psychoneuroendocrinological links between chronic stress and depression. Progress in Neuro-Psychopharmacology and Biological Psychiatry. 2003;27:893-903.

40. Tafet G. P-1403 - the Link Between Chronic Stress and Depression at the Psychological and Neurobiological Interface. European Psychiatry. 2012;27:1.

41. Ishak W, Wen R, Naghdechi L, Vanle B, Dang J, Knosp M, et al. Pain and Depression: A Systematic Review. Harvard Review of Psychiatry. 2018;26:352.

42. Craner J, Flegge L, Lake E, Perra A. Patients with Clinically Elevated Depressive Symptoms Report Improvements in Mood, Pain, and Functioning following Participation in Interdisciplinary Pain Rehabilitation. Pain medicine. 2021.

43. Li W, Liu P, Hu Y, Meng J. Pain Modulates Responses to Emotional Stimuli. Frontiers in Psychology. 2020;11.

44. Scaini S, Davies S, De Francesco S, Pelucchi A, Rubino S, Battaglia M. Altered pain perception and nociceptive thresholds in major depression and anxiety disorders: A meta-analysis. Neuroscience & Biobehavioral Reviews. 2025;169.

45. Zeng J, Liao Z, Lin A, Zou Y, Chen Y, Liu Z, et al. Poor control of pain increases the risk of depression: a cross-sectional study. Frontiers in Psychiatry. 2025;15.

46. Ojeda B, Dueñas M, Salazar A, Micó J, Torres L, Failde I. Factors Influencing Cognitive Impairment in Neuropathic and Musculoskeletal Pain and Fibromyalgia. Pain Medicine. 2018;19:499.

47. Coppieters I, Ickmans K, Cagnie B, Nijs J, De Pauw R, Noten S, et al. Cognitive Performance Is Related to Central Sensitization and Health-related Quality of Life in Patients with Chronic Whiplash-Associated Disorders and Fibromyalgia. Pain physician. 2015;18 3.

48. Nimbi F, Renzi A, Mesce M, Limoncin E, Galli F. Central sensitization symptoms in vulvodynia: exploring the role of temperament, personality traits, childhood adverse events, defense mechanisms, and mental pain on quality of life. The journal of sexual medicine. 2024.

49. Kieskamp S, Paap D, Carbo M, Wink F, Bos R, Bootsma H, et al. Central sensitization has major impact on quality of life in patients with axial spondyloarthritis. Seminars in arthritis and rheumatism. 2021;52:151933.