

Original Research Article

Broken heart syndrome-like psychosomatic dysregulation in knee osteoarthritis: a bidirectional analysis of pain-stress coupling

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ABSTRACT

Background: A prominent chronic musculoskeletal condition that is linked to pain, disability, and a lower quality of life is knee osteoarthritis (KOA). A biopsychosocial paradigm, which holds that psychological factors have a major impact on pain perception and functional limitation, is supported by emerging research. This model suggests a reciprocal relationship between emotional and physical health. Objective of the study was to evaluate gender-based variations across radiographic severity classes and to look into the relationship between pain intensity, functional impairment, and psychological distress in people with KOA.

Methods: A cross-sectional observational study was conducted among 108 patients diagnosed with KOA. The WOMAC (modified CRD Pune version) was used to assess clinical severity, while the GAD-7 and PHQ-9 were used to assess anxiety and depressive symptoms. Pain-stress correlations were evaluated using Pearson's correlation, and male and female participants with Kellgren-Lawrence (K/L) grades II and III were compared using independent-samples t-tests.

Results: Clinically significant patterns were found despite the lack of statistical significance ($p > 0.05$). Increased psychological discomfort, especially depressive symptoms, was linked to higher WOMAC scores. In female participants, there was a somewhat favorable correlation between the severity of symptoms and depression ($r = 0.374$, $p = 0.333$), but anxiety exhibited mild correlations in both sexes. Pain, stiffness, function, and overall WOMAC ratings did not differ significantly based on sex across K/L grades (all $p > 0.05$). These results point to a clinically significant connection between emotional discomfort and pain burden.

Conclusions: According to the study, there might be a reciprocal relationship between psychological distress and chronic pain, supporting a biopsychosocial view of KOA. Routine rehabilitation that incorporates psychological evaluation may improve patient results and encourage more thorough, patient-centered care.

Keywords: Knee osteoarthritis, Psychosomatic dysregulation, Pain-stress coupling, Anxiety, Depression

INTRODUCTION

Knee osteoarthritis (KOA) is one of the most prevalent chronic musculoskeletal disorders and a leading cause of pain, disability, and reduced quality of life worldwide.^{1,2} It is characterized by progressive articular cartilage degeneration, joint space narrowing, and functional

limitation, significantly impairing mobility and daily activities.^{1,2}

Although traditionally conceptualized as a structural and degenerative joint disease, growing evidence supports a biopsychosocial model, wherein psychological factors such as anxiety, depression, and emotional stress play a critical role in modulating pain perception and functional outcomes.³

According to a recent scoping analysis, psychological issues are linked to pain in up to 81% of KOA patients and physical function in 75% of them. Furthermore, KOA communities have far greater rates of anxiety and depression symptoms than the general population, which adds to the burden of symptoms and incapacity.⁴⁻⁶ New research indicates that pain and psychological distress interact in both directions through mechanisms like dysregulation of pain-modulatory pathways, altered nociceptive processing, and central sensitization, which amplifies symptoms regardless of radiographic severity.⁷⁻⁹

Despite these insights, the relationship between clinical severity and psychological distress remains underexplored in routine clinical settings, particularly with respect to sex-based differences and their interaction across radiographic grades. Therefore, the present study conceptualizes this interaction as "broken heart syndrome-like psychosomatic dysregulation," highlighting the integrative interplay between emotional distress and physical symptomatology in KOA.

METHODS

Study design

This cross-sectional time-bound study was conducted between January 2024 and September 2025 at the OPD of the Department of Orthopedics, AIIMS, Rishikesh.

Patient selection

This cross-sectional study included 108 patients (male and female) with clinically and radiographically diagnosed KOA, aged 45-70 years. Based on defined radiographic criteria, participants' unilateral or bilateral illness was categorized as Kellgren-Lawrence (K/L) grade II or III. Before inclusion, written informed consent was obtained.

A standardized pro forma was used to collect clinical and demographic data, including age, height, weight, body mass index (BMI), gender, occupation, educational status, and comorbidities. The Kellgren-Lawrence grading system (grades 0-IV) was used to classify radiographic severity, with higher grades indicating greater joint deterioration. Individuals with a Karnofsky performance status score of 80-90% and mild-to-moderate symptom severity (WOMAC pain score 1-3) were considered for inclusion.

Patients with a history of lower limb joint arthroplasty, those requiring assistive devices for ambulation, those wearing customized or prescribed footwear, those who had undergone intra-articular interventions within the previous three months, and those exhibiting notable biomechanical foot abnormalities, such as altered lateral longitudinal axis alignment, were all excluded. The Western Ontario and McMaster universities osteoarthritis index (WOMAC; modified CRD Pune version), the generalized anxiety disorder-7 (GAD-7), and the patient health questionnaire-

9 (PHQ-9) were among the validated outcome measures that each participant completed to evaluate anxiety, depression symptoms, and disease-specific clinical severity.

Statistical analysis

All statistical analyses were performed using statistical package for the social sciences (SPSS) version 17.0. Continuous variables were expressed as mean±standard deviation (SD) following assessment of normality using the Shapiro-Wilk test, while categorical variables were presented as frequencies and percentages.

For comparisons between male and female participants with K/L grades II and III, the independent-samples student's t-test was applied for normally distributed continuous variables, including WOMAC pain, stiffness, function, and total scores.

The relationship between clinical severity and psychological variables was evaluated using Pearson's correlation coefficient (*r*) to assess the strength and direction of linear associations between WOMAC scores and psychological measures, including the patient health questionnaire-9 (PHQ-9) and generalized anxiety disorder-7 (GAD-7).

Categorical variables, where applicable, were analyzed using the Chi-square test or Fisher's exact test. All tests were two-tailed, and *p* values <0.05 were considered statistically significant. Given the exploratory nature of the study, observed directional trends were also interpreted alongside statistical significance.

RESULTS

A total of 108 participants were included in the analysis, with a mean age of 50.50±0.68 years and a mean BMI of 27.24±0.44 kg/m². The majority of individuals were categorized as Kellgren-Lawrence (K/L) grade III (63.0%), indicating a higher proportion of moderate disease severity, and the cohort was predominantly female (69.4%).

Correlation analysis demonstrated no statistically significant associations between WOMAC scores and psychological variables (*p*>0.05). Anxiety (GAD-7) showed weak and inconsistent correlations with clinical severity in both males (*r*= -0.16, *p*=0.351) and females (*r*=0.075, *p*=0.556). In contrast, depressive symptoms (PHQ-9) showed a positive trend with symptom burden, with a moderate association among female participants (*r*=0.374, *p*=0.33) and a negligible association among males (*r*=0.043, *p*=0.80).

Comparative analysis across K/L grades revealed no statistically significant gender differences in WOMAC pain, stiffness, functional, or total scores (*p*>0.05). Although mean WOMAC scores were marginally higher

in males for certain parameters (e.g., pain in K/L grade II: 6.13 ± 4.69 versus 4.29 ± 2.81), these differences did not reach statistical significance, indicating comparable clinical profiles between genders across radiographic severity levels.

Table 1: Age distribution of patients.

Variables	Value	Percentage (%)
Age (years)	50.50 ± 0.68	-
45-59 years	72	66.7
59-70 years	36	33.3
BMI (kg/m²)	27.24 ± 0.44	-
Gender		
Female	75	69.4
Male	33	30.6
Education		
Female	44	40.7
Male	23	21.3
Grade		
KL grade II	40	37.0
KL grade III	68	63.0

Table 2: Correlation between WOMAC scores and psychological variables.

Variable	Male (r)	Male (p value)	Female (r)	Female (p value)
GAD-7 (anxiety)	-0.16	0.351	0.075	0.55
PHQ-9 (depression)	0.043	0.803	0.374	0.33

Table 3: Comparison of WOMAC scores between sexes across K/L grades.

Outcome	K/L grade	Male (mean $\pm$ SD)	Female (mean $\pm$ SD)	Mean difference	P value
Pain	Grade II	6.13 ± 4.69	4.29 ± 2.81	1.84	0.10
	Grade III	4.6 ± 2.64	4.21 ± 3.19	0.39	0.64
Stiffness	Grade II	2.8 ± 1.52	2.29 ± 1.19	0.51	0.22
	Grade III	4.6 ± 2.64	4.21 ± 3.19	0.39	0.64
Function	Grade II	21.93 ± 9.91	21.9 ± 7.94	0.03	0.99
	Grade III	22.25 ± 5.48	22.5 ± 7.42	-0.25	0.89
Total WOMAC	Grade II	30.87 ± 14.51	28.48 ± 10.45	2.38	0.52
	Grade III	29.7 ± 8.35	29.36 ± 10.77	0.34	0.90

Despite the lack of statistical significance, the observed distribution patterns suggest a clinically relevant trend, wherein increased pain and functional impairment may be associated with heightened psychological distress, particularly depressive symptomatology in female participants. These findings underscore the potential influence of psychosomatic interactions in KOA, independent of structural disease severity.

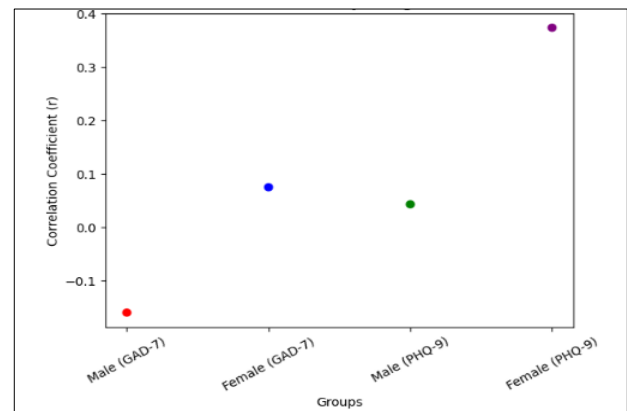


Figure 1: Scatter chart of correlation of WOMAC scores and psychological variables.

DISCUSSION

The current study assessed the association between psychological distress and clinical severity in patients with KOA, with an emphasis on gender-based variations and the coupling of pain and stress. The results show persistent directional trends, suggesting a possible interaction between symptom load and psychological factors within a biopsychosocial framework, even though statistical significance was not achieved.^{10,11}

A key observation of this study is the relatively stronger association between depressive symptoms and clinical severity, particularly among female participants. This aligns with existing evidence indicating that depression may play a central role in modulating pain perception and functional limitation in chronic musculoskeletal conditions.^{12,13} Mechanistically, such associations may be explained by central sensitization, altered nociceptive signaling, and impaired descending inhibitory pathways, which collectively contribute to the amplification of pain perception independent of structural joint damage.^{14,15} This supports emerging evidence that pain experience in osteoarthritis is not solely dependent on structural pathology but is significantly influenced by central and psychosocial mechanisms. These findings reinforce the concept that symptom severity in KOA cannot be fully explained by radiographic changes alone.

In contrast, anxiety demonstrated weak and inconsistent associations with WOMAC scores across both sexes, suggesting a comparatively limited role in influencing clinical severity within this cohort. This differential pattern

between anxiety and depression is consistent with emerging literature indicating that depressive symptomatology may have a more sustained and clinically relevant impact on chronic pain states and disability progression.

The absence of statistically significant sex-based differences across Kellgren-Lawrence grades further highlights that structural disease severity does not necessarily correspond with perceived symptom burden. Despite similar radiographic profiles, variations in psychological status may contribute to differences in pain experience, underscoring the importance of individualized, multidimensional assessment strategies.

The findings of this study support a biopsychosocial understanding of KOA, in which physical pathology, psychological factors, and neurobiological mechanisms interact to shape the overall clinical experience.

Limitations

Several limitations of the study should be acknowledged. First, the cross-sectional design precludes establishing causal relationships between psychological distress and clinical severity. Second, the relatively modest sample size may have limited the statistical power to detect significant associations. Third, the use of self-reported psychological measures (PHQ-9 and GAD-7) introduces the potential for reporting bias and subjective variability.

Additionally, the study did not incorporate objective biological or neurophysiological markers that could provide deeper insight into the underlying mechanisms. Finally, the findings may be limited in their generalizability due to the specific demographic and clinical characteristics of the study population.

Future research that incorporates larger, multicenter cohorts and longitudinal designs, and integrates objective biomarkers, is imperative to elucidate further the complex relationship between pain and psychological factors in KOA.

CONCLUSION

This study reinforces a biopsychosocial perspective of knee osteoarthritis, highlighting that psychological factors—particularly depressive symptoms—demonstrate directional associations with pain severity and functional impairment, even in the absence of statistical significance. Radiographic severity alone does not adequately explain symptom burden, underscoring the importance of multidimensional assessment. Embedding routine psychological screening into KOA management may enable more holistic, patient-centered care, improving functional outcomes through targeted multidisciplinary interventions. Future research embedding larger, multicenter cohorts and longitudinal designs, together with objective biomarker integration, is imperative to clarify the

complex interplay between pain and psychological factors in KOA.

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