Mental Health and Lifestyle Journal

Year 2027
Volume 5
Issue 4

The Effect of Sleep Quality on Perceived Stress in Patients With Chronic Pain: The Mediating Role of Rumination

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Article type:
Original Research

Article history:
Received 16 July 2026
Revised 28 September 2026
Accepted 09 October 2026
Initial Publish 21 October 2026
Published online 01 July 2027

ABSTRACT

This study aimed to investigate the effect of sleep quality on perceived stress in patients with chronic pain and to determine the mediating role of rumination in this relationship. This applied study employed a descriptive-correlational design using structural equation modeling. The statistical population consisted of individuals diagnosed with chronic pain who attended pain treatment clinics and physiotherapy centers in western Tehran between June and August 2026. A total of 150 eligible patients were selected through purposive sampling. Data were collected using the Pittsburgh Sleep Quality Index, the Cohen Perceived Stress Scale, and the Nolen-Hoeksema Ruminative Responses Scale. Data analysis was conducted using SPSS version 27 and SmartPLS version 3. Pearson correlation analysis was used to examine bivariate relationships among the study variables, and partial least squares structural equation modeling was applied to test the direct and indirect effects within the proposed conceptual model. Sleep quality had a significant positive direct effect on perceived stress ($\beta = .379$, $t = 4.580$, $p < .01$) and rumination ($\beta = .647$, $t = 12.673$, $p < .01$). Rumination also had a significant positive effect on perceived stress ($\beta = .428$, $t = 6.568$, $p < .01$). The indirect effect of sleep quality on perceived stress through rumination was statistically significant ($\beta = .277$, $t = 5.382$, $p < .01$), with a variance accounted for value of 42.2%, indicating partial mediation. The model explained 53.7% of the variance in perceived stress ($R^2 = .537$), and the predictive relevance index was satisfactory ($Q^2 = .329$). The overall goodness-of-fit index was .533, indicating an acceptable structural model. Poorer sleep quality is associated with higher perceived stress among patients with chronic pain, both directly and indirectly through increased rumination. Rumination therefore appears to be an important cognitive mechanism linking sleep disturbance to psychological stress in this population and may represent a relevant target for psychological interventions designed to reduce stress and improve adjustment to chronic pain.

Keywords: sleep quality, perceived stress, rumination, chronic pain.

How to cite this article:
Amraeipour, S., & Rostamnezhad, M. (2027). The Effect of Sleep Quality on Perceived Stress in Patients With Chronic Pain: The Mediating Role of Rumination. *Mental Health and Lifestyle Journal, 5*(4), 1-17. https://doi.org/10.61838/mhlj.328

Introduction

Chronic pain is a complex and persistent health condition that extends beyond the sensory experience of pain and affects multiple dimensions of psychological, behavioral, and social functioning. Unlike acute pain, which generally serves an adaptive warning function and tends to resolve as tissue healing progresses, chronic pain persists over extended periods and frequently becomes intertwined with emotional distress, cognitive preoccupation, sleep disturbance, impaired functioning, and reduced quality of life. For individuals living with persistent or recurrent pain, the experience of pain may create an enduring state of physiological and psychological vigilance in which attention is repeatedly directed toward bodily sensations, anticipated

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exacerbations, limitations in daily activities, and concerns about the future. Such circumstances may increase vulnerability to perceived stress, particularly when individuals judge environmental demands, symptoms, and functional limitations as exceeding their available coping resources. Perceived stress is not simply determined by exposure to objectively stressful circumstances but reflects an individual's appraisal of the unpredictability, uncontrollability, and burden associated with internal and external demands. Evidence from broader health contexts indicates that perceived stress is shaped by the interaction between situational pressures and psychosocial resources, suggesting that subjective appraisal is an important mechanism through which ongoing health-related demands may influence psychological functioning (1). In chronic pain populations, this appraisal process is especially relevant because symptoms are often recurrent, difficult to predict, and only partially controllable, potentially increasing feelings of helplessness and psychological overload. At the same time, chronic pain commonly co-occurs with disrupted sleep, and psychosocial characteristics appear to be strongly associated with both sleep duration and sleep quality in individuals experiencing chronic pain (2). These interrelationships suggest that understanding perceived stress in chronic pain requires attention not only to pain itself, but also to modifiable behavioral and cognitive factors that may amplify or sustain stress-related responses.

Sleep quality represents one of the most clinically relevant factors in this context because sleep and pain are dynamically and reciprocally related. Sleep is essential for emotional regulation, cognitive restoration, physiological recovery, and adaptive stress responding, whereas inadequate or fragmented sleep may increase affective instability, impair executive control, and heighten sensitivity to aversive stimuli. Among individuals with chronic pain, difficulties initiating sleep, maintaining sleep, obtaining restorative sleep, and functioning effectively during the daytime are highly salient concerns. Poor sleep may result from pain-related discomfort and nocturnal awakenings, yet sleep disturbance may itself contribute to greater emotional reactivity and a reduced capacity to cope with persistent symptoms. Importantly, studies of adults with chronic pain have shown that sleep quality is related not only to physical health but also to psychosocial characteristics, underscoring the importance of considering psychological factors in understanding sleep impairment within this population (2). Research in other psychologically vulnerable groups similarly indicates that sleep quality is closely associated with emotional and cognitive functioning. For example, mindfulness-based cognitive therapy has been associated with improvements in sleep quality alongside changes in positive and negative emotions and rumination among women with irritable bowel syndrome, a condition in which recurrent physical symptoms and psychological distress often coexist (3). Such findings reinforce the view that sleep problems should not be conceptualized as an isolated physiological phenomenon. Rather, sleep quality may be embedded in a broader network of cognitive-emotional processes that determine how individuals interpret, respond to, and recover from ongoing stressors. Accordingly, in chronic pain, poor sleep may be particularly consequential because patients are already exposed to repeated symptom-related demands, and reduced restorative sleep may weaken their capacity to regulate negative thoughts and emotional responses.

The association between sleep quality and perceived stress has received increasing empirical attention, and contemporary evidence suggests that this relationship may be partly explained by cognitive processes occurring between stressful experiences and sleep-related outcomes. Stress can interfere with sleep through heightened physiological arousal, anticipatory concern, and persistent cognitive activity, while insufficient

or poor-quality sleep may subsequently increase the subjective intensity of stress by impairing emotion regulation and coping. Recent research examining the pathways through which stress affects sleep has shown that rumination can function as an important intermediary mechanism linking stress to poorer sleep outcomes (4). Similarly, meta-analytic structural equation modeling has demonstrated that perseverative cognition mediates the association between perceived stress and sleep disturbance, providing evidence that continued mental engagement with stressful material may prolong the effects of stress beyond the immediate occurrence of the stressor (5). From this perspective, stress-related cognition may sustain emotional and physiological activation at times when recovery would otherwise occur, including during the period preceding sleep. Daily-process research also demonstrates meaningful associations among stress-related rumination, sleep, and diurnal cortisol activity, suggesting that repetitive thought about stressors is embedded in both psychological and physiological stress-regulation systems (6). These findings are highly relevant to chronic pain because pain itself can function as a persistent stressor that repeatedly captures attention. When poor sleep and chronic pain occur simultaneously, the individual may have fewer cognitive resources available to disengage from distressing thoughts, potentially creating a cycle in which sleep disturbance, repetitive thinking, and perceived stress reinforce one another.

Rumination is therefore a particularly important candidate mechanism for explaining how sleep quality may be related to perceived stress among people with chronic pain. Rumination refers to repetitive, persistent, and relatively inflexible thinking about distress, its causes, meanings, and consequences. Although reflective thought may sometimes facilitate understanding or problem solving, maladaptive rumination is generally characterized by recurrent negative thinking that does not lead to effective resolution of the underlying problem. Contemporary conceptualizations increasingly situate rumination within the broader construct of repetitive negative thinking, which has been described as a transdiagnostic cognitive process associated with a wide range of emotional disorders and psychological difficulties (7). The transdiagnostic significance of repetitive negative thinking is especially important because it implies that rumination is not restricted to depression or any single diagnostic category; instead, it may operate across conditions by maintaining negative affect, interfering with adaptive coping, and prolonging cognitive-emotional activation. In chronic pain, individuals may ruminate not only about negative mood but also about pain intensity, treatment outcomes, functional losses, sleep problems, interpersonal consequences, and anticipated future difficulties. Such repetitive cognition may narrow attentional focus toward threat and uncontrollability, thereby increasing perceived stress. This mechanism is also theoretically consistent with findings that cognitive perseveration can connect stress to sleep disturbance (5) and that stress-related rumination is associated with both sleep patterns and biological stress markers (6). Thus, rumination may represent a psychological bridge between impaired sleep and elevated stress, particularly in populations exposed to enduring and difficult-to-control physical symptoms.

A growing body of research directly supports the relationship between rumination and sleep disturbance. In young adults, poor sleep quality has been examined in relation to chronotype and rumination, with findings highlighting rumination as a relevant cognitive correlate of compromised sleep (8). Among university students showing a tendency toward generalized anxiety disorder, metacognitive beliefs, rumination, and sleep have also been found to be meaningfully interrelated, further supporting the role of repetitive negative thinking in sleep-related difficulties among individuals vulnerable to psychological

distress (9). Research focusing on female students has likewise demonstrated associations among depressive symptoms, sleep-wake characteristics, insomnia, and rumination, indicating that rumination may contribute to the psychological processes through which mood-related difficulties coexist with disrupted sleep (10). At the daily level, fluctuations in rumination have also been associated with sleep outcomes. Research among adolescents, for instance, has examined daily links among loneliness, rumination, and sleep, suggesting that day-to-day cognitive-emotional experiences may carry over into nocturnal functioning (11). Although these studies involve different populations, their convergence is noteworthy: across developmental stages and psychological contexts, repetitive negative thinking appears consistently connected with sleep-related functioning. This consistency provides a strong rationale for examining rumination in chronic pain, where intrusive physical sensations and uncertainty about symptom persistence may provide repeated triggers for negative self-focused thought. In such patients, poor sleep may reduce inhibitory control over repetitive thoughts, while rumination may further impair emotional recovery and intensify the subjective burden of stress.

Evidence from occupational and intervention research further strengthens the proposed relationships among sleep, rumination, and stress. Among female prehospital emergency personnel, rumination has been investigated as a mediator linking occupational stress and chronic fatigue with sleep quality, suggesting that repetitive cognition may transmit or intensify the effects of stress-related occupational demands on sleep (12). Although emergency staff differ from chronic pain patients in the source of their stress exposure, both groups may experience sustained demands, fatigue, and difficulty disengaging cognitively from distressing experiences. The mediating role of rumination in such contexts suggests that repetitive negative thinking is not merely a correlate of stress or sleep disturbance but may operate as a pathway connecting these domains. Intervention evidence also provides indirect support for this interpretation. Acceptance and commitment therapy has been shown to influence sleep, rumination, and psychological flexibility among nurses, indicating that therapeutic modification of maladaptive cognitive processes may coincide with improvements in sleep-related outcomes (13). Similarly, mindfulness-based cognitive therapy has demonstrated beneficial effects on sleep quality and rumination in women with irritable bowel syndrome (3). Together, these findings suggest that sleep disturbance and rumination may be modifiable rather than fixed characteristics and that their relationship has practical implications for psychological interventions. If rumination accounts for part of the relationship between poor sleep and perceived stress in chronic pain, interventions that improve sleep while simultaneously reducing repetitive negative thinking may have greater potential to decrease psychological distress than approaches targeting either process in isolation.

The directionality of the relationships among sleep, rumination, and stress is likely to be complex rather than strictly linear. Research has often examined the effect of stress on sleep, showing that greater stress is associated with poorer sleep and that rumination may partly mediate this association (4). However, there are strong theoretical grounds for examining the pathway in the reverse direction as well, particularly when sleep quality is operationalized as a relatively broad indicator of sleep difficulties. Poor sleep can compromise prefrontal cognitive control, increase emotional reactivity, and reduce the capacity to disengage from negative stimuli, all of which may make repetitive negative thought more likely. Once activated, rumination may magnify the subjective impact of daily difficulties and contribute to a heightened perception that situations are overwhelming or uncontrollable. This interpretation is compatible with the

transdiagnostic framework of repetitive negative thinking, in which maladaptive repetitive cognition is understood as a process capable of maintaining distress across different symptom domains (7). It is also consistent with evidence showing that repetitive cognition mediates associations between perceived stress and sleep disturbance (5), that rumination is associated with poor sleep quality in young adults (8), and that metacognitive and ruminative processes are linked to sleep problems in anxiety-prone populations (9). Accordingly, a mediation model in which sleep quality predicts perceived stress both directly and indirectly through rumination is theoretically plausible. Importantly, because higher scores on the Pittsburgh Sleep Quality Index indicate poorer sleep quality, a positive statistical relationship between PSQI scores and perceived stress should be interpreted as indicating that greater sleep impairment is associated with higher perceived stress.

Despite increasing research on the connections among stress, sleep, and repetitive cognition, several gaps remain. First, much of the existing literature has examined healthy adolescents, university students, occupational groups, or individuals with specific psychological vulnerabilities rather than patients with chronic pain (9, 11, 13). Second, several studies have conceptualized stress primarily as an antecedent of sleep problems, whereas comparatively less attention has been devoted to testing models in which poor sleep contributes to perceived stress through cognitive mechanisms (4, 5). Third, although chronic pain research has identified meaningful psychosocial correlates of sleep quality (2), the mediating role of rumination in the association between sleep quality and perceived stress remains insufficiently examined in this clinical population. This gap is important because chronic pain creates conditions that are especially conducive to repetitive negative thinking: symptoms may be persistent, unpredictable, difficult to control, and disruptive to occupational, interpersonal, and recreational functioning. At the same time, sleep problems may diminish psychological resilience and increase the likelihood that pain-related and stress-related thoughts persist without resolution. Studies showing that rumination is connected with sleep disturbance in young adults (8), with insomnia and sleep-wake characteristics in female students (10), with daily sleep outcomes in adolescents (11), and with occupational stress and sleep quality in healthcare personnel (12) collectively support the need to investigate whether a similar mechanism operates among patients with chronic pain. Clarifying these relationships may contribute to a more integrated biopsychological understanding of chronic pain by identifying a potentially modifiable cognitive mechanism through which sleep difficulties are associated with heightened stress.

From a clinical perspective, identifying rumination as a mediator would also have implications for assessment and intervention. Psychological management of chronic pain increasingly requires attention to factors that perpetuate distress beyond the immediate nociceptive experience. If sleep disturbance contributes to perceived stress partly through rumination, routine assessment of chronic pain patients may benefit from evaluating not only pain intensity and sleep quality but also repetitive patterns of negative thinking. Such an approach is supported by intervention studies indicating that therapies capable of modifying rumination, psychological flexibility, and sleep-related functioning may produce concurrent improvements across multiple domains (3, 13). Moreover, understanding the indirect pathway through rumination may help explain why patients with apparently comparable pain severity and sleep difficulties can differ considerably in their levels of subjective stress. Individuals who are better able to disengage from repetitive negative thoughts may experience less psychological amplification of sleep-related and pain-

related difficulties, whereas those with stronger ruminative tendencies may remain cognitively engaged with their symptoms and stressors for prolonged periods. This possibility is consistent with the broader literature conceptualizing repetitive negative thinking as a central process that cuts across conventional diagnostic boundaries (7). Examining this mechanism through structural equation modeling can therefore provide a more nuanced account of both direct and indirect relationships among sleep quality, rumination, and perceived stress and may offer empirically grounded targets for psychological interventions among people living with chronic pain.

Accordingly, the present study aimed to investigate the effect of sleep quality on perceived stress in patients with chronic pain and to determine whether rumination mediates this relationship.

Methods and Materials

Study Design and Participants

In terms of purpose, the present study was applied research, and in terms of its nature and methodology, it was a descriptive-correlational study conducted within a structural equation modeling framework.

The statistical population of this study consisted of all individuals diagnosed with chronic pain (persistent or recurrent pain) who referred to pain treatment clinics located in western Tehran to receive therapeutic services between June 2026 and August 2026. The study sample consisted of 150 individuals with chronic pain who were selected through purposive sampling. This sample size was determined based on the presence of three variables, with 50 participants considered for each variable. The inclusion criteria consisted of a clinical diagnosis of chronic pain by a specialist, being 18 years of age or older, having the ability to read and write, and providing informed willingness to participate in the study.

Following approval of the research proposal by the University Research Council, the required permissions for conducting the study were obtained, and ethical approval was granted by the University Research Ethics Committee under the code IR.IAU.LIAU.REC.1405.052. Subsequently, the necessary arrangements were made with the administrators of pain clinics and physiotherapy centers located in western Tehran. After the required coordination had been completed, the researcher attended the aforementioned centers between June 2026 and August 2026. In the first stage, patients with chronic pain were identified in cooperation with physicians and healthcare staff based on their medical records or diagnoses made by specialist physicians. The inclusion and exclusion criteria were then assessed for each individual, and patients who met the eligibility criteria were considered eligible for participation. Sampling was conducted purposively; specifically, among eligible patients attending the healthcare centers, individuals who were willing to participate and met the inclusion criteria were enrolled in the study. This process continued until the target sample size of 150 participants was reached. Before implementation of the study, the objectives, significance, and procedures of the research were fully explained to the participants. They were assured that participation was entirely voluntary, that their information would remain confidential, and that the findings would be reported solely for research purposes. After these explanations were provided, informed consent was obtained from all participants. Subsequently, the Pittsburgh Sleep Quality Index, Cohen Perceived Stress Scale, Nolen-Hoeksema Ruminative Responses Scale, and a demographic information form were administered to the participants. The questionnaires were completed individually in a quiet setting, and the researcher was present throughout the process to provide any necessary clarification regarding

questionnaire completion. The average time required to complete the full set of research instruments was approximately 20 to 30 minutes. After questionnaire collection, all response forms were examined for completeness, legibility, and usability. Incomplete or damaged questionnaires were excluded from the study, and the resulting data were coded and subjected to statistical analysis.

Data Collection Tools

1. Cohen et al. Perceived Stress Scale (1984): The Cohen Perceived Stress Scale consists of 14 items and was designed to assess the extent to which individuals perceived their lives as stressful during the preceding month. The instrument evaluates the extent to which individuals perceive life events as being beyond their control or, conversely, as manageable. Responses are scored on a five-point Likert scale ranging from never (0) to very often (4). Of the 14 items, seven are positively worded and seven are negatively worded, with the negatively worded items being reverse-scored. The total score ranges from 0 to 56, with higher scores indicating greater perceived stress. The questionnaire has demonstrated adequate construct validity and substantial correlations with related psychometric criteria. In the study by Saadat et al. (2015), the validity of the questionnaire was confirmed by university faculty members and subject-matter experts, and its Cronbach's alpha coefficient was reported to be greater than .70 (Saadat et al., 2015). In the present study, the internal consistency of the Perceived Stress Scale was assessed using Cronbach's alpha, yielding a coefficient of .969.

2. Nolen-Hoeksema and Morrow Ruminative Responses Scale (1991): The Nolen-Hoeksema Ruminative Responses Scale consists of 22 items and assesses the degree of rumination experienced by individuals when confronted with problems and negative thoughts. This self-report instrument comprises two subscales: depressive brooding, involving a focus on the causes and consequences of negative emotions, and reflective/analytical rumination, involving repetitive negative thoughts without active attempts at problem solving. Responses are scored on a four-point Likert scale ranging from never to always and are assigned scores from 1 to 4, respectively. The total score ranges from 22 to 88, with higher scores representing a greater severity of rumination. Bagherinejad, Salehi Fadardi, and Tabatabaei (2010) reported evidence of predictive validity, demonstrating that rumination could significantly predict depression. Furthermore, the findings of Vesal and Nazarinia (2016) indicated acceptable validity for this questionnaire. Ansari, Dowlatshahi, and Sahaf (2019) reported a Cronbach's alpha coefficient of .86 for this instrument. In the present study, Cronbach's alpha was .974, indicating satisfactory reliability of the instrument in the study sample.

3. Pittsburgh Sleep Quality Index: The Pittsburgh Sleep Quality Index (PSQI) is a self-report instrument designed to assess an individual's sleep quality during the preceding month. The questionnaire consists of 19 self-report items that, according to the scoring instructions, are organized into seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Each of these seven components is assigned a score ranging from 0 to 3, and the sum of the component scores constitutes the global sleep quality score, which ranges from 0 to 21. Higher scores indicate poorer sleep quality and greater sleep-related problems. The instrument has demonstrated satisfactory validity and reliability. In the study by Kakouei et al. (2010),

the content validity of the questionnaire was confirmed, and Buysse et al. (1989) reported a Cronbach's alpha coefficient of .83. In the present study, Cronbach's alpha for the Pittsburgh Sleep Quality Index was .904.

Data Analysis

For the analysis of the research data, the collected data were first entered into SPSS version 27. Following preliminary screening, missing data, outliers, and potential data-entry errors were examined and controlled. Descriptive statistics, including the mean, standard deviation, minimum, and maximum scores, were then used to describe the demographic characteristics of the sample and the research variables. Subsequently, partial least squares structural equation modeling (PLS-SEM) was conducted using SmartPLS version 3 to examine the relationships among the study variables and test the proposed conceptual model.

Findings and Results

A total of 150 patients with chronic pain participated in the present study. Of these participants, 92 (61.3%) were women and 58 (38.7%) were men. The mean age of the participants was 41.62 years (SD = 10.84). The largest age group consisted of participants aged 41–50 years, with 46 individuals (30.7%), whereas the smallest group consisted of participants aged 18–30 years, with 24 individuals (16%). Regarding marital status, 101 participants (67.3%) were married, 36 (24%) were single, and 13 (8.7%) were divorced or widowed. Regarding educational level, the largest proportion of participants held a bachelor's degree, comprising 61 individuals (40.7%). With respect to the duration of chronic pain, the largest group consisted of patients who had experienced chronic pain for more than one year and up to three years, accounting for 66 participants (44%) of the sample.

To examine the status of the main research variables, descriptive indices including the mean, standard deviation, minimum score, and maximum score were calculated. The results are presented in Table 1.

Table 1. Descriptive Statistics for the Research Variables

Variable	Mean	SD	Minimum	Maximum
Sleep quality	10.47	3.705	0	20
Perceived stress	26.92	10.284	2	52
Rumination	65.80	14.021	29	104

As shown in Table 1, the mean sleep quality score was 10.47 (SD = 3.705), the mean perceived stress score was 26.92 (SD = 10.284), and the mean rumination score was 65.80 (SD = 14.021). Furthermore, the skewness and kurtosis values of the study variables were within acceptable ranges, and no substantial deviation from normality was observed for the variables under investigation.

Table 2. Correlation Matrix Among the Research Variables

Variable	Sleep Quality	Perceived Stress	Rumination
Sleep quality	1	.611**	.601**
Perceived stress	—	1	.648**
Rumination	—	—	1

The results indicated a positive and statistically significant relationship between sleep quality score and perceived stress, $r = .611$, $p < .01$. A positive and statistically significant relationship was also observed between sleep quality and rumination, $r = .601$, $p < .01$. Furthermore, the relationship between rumination

and perceived stress was positive and statistically significant, $r = .648$, $p < .01$, representing the strongest correlation among the study variables.

Considering the scoring procedure of the Pittsburgh Sleep Quality Index, higher scores indicate poorer sleep status. Therefore, the findings demonstrate that greater sleep problems are associated with higher levels of rumination and perceived stress.

Before examination of the structural model, the adequacy of the data for factor analysis was evaluated. The Kaiser–Meyer–Olkin (KMO) measure was .722, indicating adequate sampling adequacy for factor analysis. Bartlett's test of sphericity was also statistically significant, $\chi^2(3) = 167.073$, $p < .001$. Therefore, the correlation matrix was considered appropriate for subsequent analyses.

To evaluate the measurement model, the internal reliability of the constructs was examined using Cronbach's alpha and composite reliability, whereas convergent validity was assessed using the average variance extracted (AVE). The results are presented in Table 3.

Table 3. Reliability and Convergent Validity Indices for the Research Constructs

Construct	Cronbach's α	Composite Reliability (CR)	AVE
Sleep quality	.904	.903	.572
Perceived stress	.969	.969	.689
Rumination	.974	.973	.623

The results indicated that Cronbach's alpha and composite reliability coefficients for all constructs exceeded .70, demonstrating satisfactory reliability of the measurement instruments. Furthermore, the AVE values for all constructs exceeded .50; therefore, the convergent validity of the measurement model was also considered acceptable.

In addition, none of the factor loadings of the examined items was below .50; therefore, no items were removed from the measurement model.

Following confirmation of the measurement model, the coefficient of determination (R^2), predictive relevance (Q^2), and overall goodness-of-fit (GOF) index were examined to evaluate the structural model. The results are presented in Table 4.

Table 4. Structural Model Evaluation Indices

Index	Value
R^2 for perceived stress	.537
Q^2 for perceived stress	.329
GOF	.533

The coefficient of determination for perceived stress was $R^2 = .537$. Thus, the predictor variables included in the model accounted for 53.7% of the variance in perceived stress. Furthermore, the Q^2 value for perceived stress was .329, indicating that the model possessed adequate predictive relevance.

In the assessment of the overall fit of the model, the mean communality was .663 and the mean coefficient of determination was .429. Based on these values, the GOF index was calculated as .533. This value indicated satisfactory overall predictive performance of the model for the endogenous research variable.

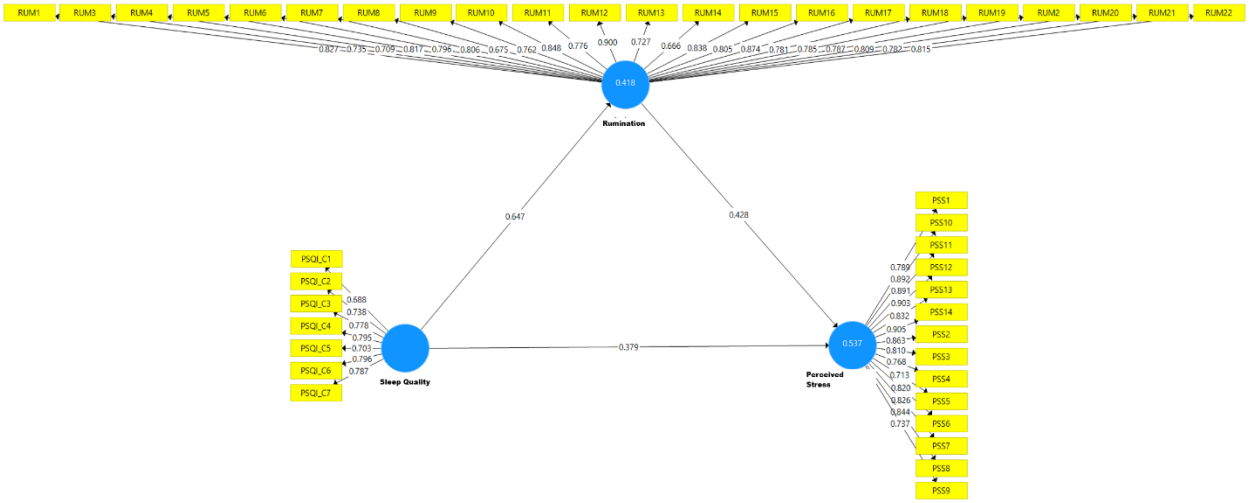


Figure 1. Structural Model of the Study and Standardized Path Coefficients

As illustrated in Figure 1, all path coefficients in the proposed research model were positive. The largest path coefficient corresponded to the effect of sleep quality on rumination, followed by the effect of rumination on perceived stress and the direct effect of sleep quality on perceived stress. The statistical significance of these paths is presented in Table 5.

To test the research hypotheses, standardized path coefficients and *t* statistics were examined within the structural model. The results are presented in Table 5.

Table 5. Results of Testing the Direct and Indirect Paths in the Structural Model

No.	Path	Path Coefficient (β)	*t* Value	Result
1	Sleep quality → Perceived stress	.379	4.580	Supported
2	Sleep quality → Rumination	.647	12.673	Supported
3	Rumination → Perceived stress	.428	6.568	Supported
4	Sleep quality → Rumination → Perceived stress	.277	5.382	Supported

The results indicated that the direct effect of sleep quality on perceived stress was positive and statistically significant, β = .379, t = 4.580, p < .01. Furthermore, the direct effect of sleep quality on rumination was positive and statistically significant, β = .647, t = 12.673, p < .01. Finally, the direct effect of rumination on perceived stress was also positive and statistically significant, β = .428, t = 6.568, p < .01. Therefore, all direct paths in the structural model were statistically significant.

The analysis of the indirect effect indicated that sleep quality had a positive and statistically significant indirect effect on perceived stress through rumination, β = .277, t = 5.382, p < .01. The variance accounted for (VAF) value was .422, or 42.2%, indicating that part of the effect of sleep quality on perceived stress was transmitted through rumination. Because both the direct and indirect effects were statistically significant, rumination served as a partial mediator in the relationship between sleep quality and perceived stress. Accordingly, the primary hypothesis of the study was supported.

Discussion and Conclusion

The present study investigated the effect of sleep quality on perceived stress in patients with chronic pain, with particular emphasis on the mediating role of rumination. The findings supported the proposed conceptual model and demonstrated that sleep quality had a significant direct effect on perceived stress,

sleep quality had a significant effect on rumination, and rumination significantly predicted perceived stress. In addition, the indirect effect of sleep quality on perceived stress through rumination was statistically significant, indicating a partial mediating role for rumination. The structural model showed that sleep quality and rumination jointly explained 53.7% of the variance in perceived stress, while the predictive relevance index indicated an acceptable predictive capacity of the model. The overall goodness-of-fit index also supported the adequacy of the proposed structural model. Because higher scores on the Pittsburgh Sleep Quality Index indicate poorer sleep quality, the positive path coefficients observed in this study should be interpreted as showing that greater sleep disturbance is associated with higher rumination and greater perceived stress. Taken together, these findings suggest that sleep-related difficulties in patients with chronic pain may contribute to psychological stress both directly and through their association with repetitive negative thinking.

The first major finding showed that poorer sleep quality was significantly associated with higher perceived stress among patients with chronic pain. This finding is consistent with evidence indicating that sleep quality is closely related to psychosocial functioning among individuals living with chronic pain. Zaidel and colleagues found that psychosocial factors were significantly associated with sleep quality and sleep duration in older adults with chronic pain, highlighting the psychological consequences of disturbed sleep in this population (2). The present finding is also compatible with studies showing that stress and sleep are strongly interconnected and that deterioration in one domain may adversely affect the other. Zhang and colleagues demonstrated that stress exerts a significant influence on sleep quality and that this relationship is partly transmitted through cognitive-emotional mechanisms (4). Although the direction of prediction in that study was from stress to sleep, the relationship between the two variables is likely reciprocal, and the present results extend the existing literature by demonstrating that poorer sleep quality may also contribute to greater subjective stress. Such bidirectionality is especially plausible in chronic pain because persistent pain can interfere with sleep initiation, sleep continuity, and restorative sleep, while inadequate sleep may reduce patients' capacity to cope effectively with pain and daily environmental demands.

The direct association between poor sleep quality and perceived stress can be explained through several psychological and physiological mechanisms. Restorative sleep contributes to emotional regulation, cognitive control, physiological recovery, and regulation of stress-responsive systems. When sleep is fragmented or insufficient, individuals may show increased emotional reactivity, reduced frustration tolerance, impaired attentional regulation, and diminished capacity to cognitively reappraise difficult experiences. These processes may be particularly relevant in chronic pain, where patients are repeatedly exposed to uncomfortable sensations, uncertainty regarding symptom recurrence, treatment demands, and restrictions in occupational or interpersonal functioning. In this context, poor sleep may reduce the psychological resources available for coping with these challenges, causing ordinary difficulties or pain-related experiences to be evaluated as more unpredictable, uncontrollable, or overwhelming. Research on perceived stress has emphasized the importance of subjective appraisal in determining how individuals respond psychologically to environmental demands (1). Therefore, the finding that poor sleep predicts perceived stress is theoretically consistent with the possibility that sleep impairment reduces coping capacity and alters the appraisal of ongoing pain-related and non-pain-related demands.

The second important finding was that poorer sleep quality significantly predicted higher rumination, and this relationship represented the strongest standardized path in the model. This result is consistent with a growing body of evidence demonstrating close associations between sleep disturbance and repetitive negative thinking. Nowakowska-Domagała and colleagues reported that rumination plays an important role in the relationship between chronotype and poor sleep quality among young adults, suggesting that maladaptive repetitive cognition and sleep functioning are closely intertwined (8). Similarly, Yu and colleagues showed significant associations among metacognition, rumination, and sleep among university students with a tendency toward generalized anxiety disorder (9). Research among female students has likewise demonstrated that rumination is related to depressive symptoms, sleep-wake characteristics, and insomnia (10). Daily-process evidence further supports this connection, as Bui and colleagues examined daily associations among loneliness, rumination, and sleep outcomes, indicating that repetitive cognitive activity may fluctuate alongside changes in sleep from day to day (11). The current findings therefore extend previous observations to patients with chronic pain and suggest that impaired sleep may be accompanied by greater difficulty disengaging from repetitive and negatively valenced thoughts.

Several mechanisms may explain why poorer sleep quality is associated with greater rumination in chronic pain. Sleep disturbance may compromise executive functions involved in attentional shifting, inhibitory control, and cognitive flexibility. As these regulatory capacities weaken, individuals may find it more difficult to disengage from pain-related thoughts, negative interpretations, concerns about future functioning, or memories of previous painful experiences. Chronic pain also provides a highly salient and recurrent internal stimulus that can repeatedly capture attention. Consequently, an individual who sleeps poorly may begin the day with reduced cognitive resources and may be especially vulnerable to perseverative thinking when confronted with pain or stress. This interpretation accords with the contemporary conceptualization of repetitive negative thinking as a transdiagnostic process rather than a symptom restricted to a single psychiatric disorder (7). Moulds and McEvoy emphasized that repetitive negative thinking can maintain emotional distress across diagnostic categories, which is highly relevant to chronic pain because patients may ruminate about symptoms, disability, treatment effectiveness, loss of control, and anticipated deterioration. Therefore, the strong path from sleep quality to rumination found in the present study may reflect the interaction between reduced cognitive-emotional regulation caused by poor sleep and the persistent presence of pain-related material that can trigger repetitive thinking.

The third finding indicated that rumination had a significant positive effect on perceived stress. This result is consistent with the broader literature on repetitive negative thinking and perseverative cognition. Moulds and McEvoy described repetitive negative thinking as a transdiagnostic cognitive mechanism that can maintain and intensify psychological distress by prolonging attention to negative information and reducing engagement in adaptive problem solving (7). Sladek and colleagues also found meaningful associations among daily stress-related rumination, sleep, and diurnal cortisol activity, suggesting that rumination is not only a cognitive phenomenon but may also be linked with sustained physiological stress activation (6). Similarly, Zagaria and colleagues demonstrated through a structural equation modeling meta-analysis that perseverative cognition mediates the relationship between perceived stress and sleep disturbance (5). Although their model evaluated perseverative cognition as a mediator from stress to sleep disturbance, their findings support the broader proposition that repetitive cognition is a key mechanism

connecting stress and sleep-related processes. The present findings add to this evidence by showing that among patients with chronic pain, individuals who engage in more rumination also report higher perceived stress.

Rumination may increase perceived stress because it prolongs psychological engagement with stressors after the original event or sensation has passed. Rather than allowing emotional and physiological recovery, repetitive thinking repeatedly reactivates concerns, negative interpretations, and anticipated threats. In chronic pain, rumination may involve questions about why the pain continues, whether it will worsen, whether treatment will be effective, how symptoms will affect employment or family responsibilities, and whether normal functioning can be restored. Such repetitive cognitive processing may make pain-related problems appear more pervasive and less manageable. Moreover, rumination generally does not produce effective solutions; instead, it may strengthen feelings of helplessness and uncontrollability. Since perceived stress depends heavily on the appraisal of demands relative to available coping resources, sustained rumination may shift this appraisal toward greater perceived burden. This interpretation is consistent with findings demonstrating associations between stress, rumination, and sleep quality (4) and with research showing that metacognitive and ruminative processes are associated with sleep and anxiety-related vulnerability (9). Thus, rumination may intensify the subjective experience of stress by repeatedly directing attention toward unresolved difficulties while simultaneously reducing engagement in adaptive coping.

The central finding of the study was that rumination significantly mediated the relationship between sleep quality and perceived stress. The indirect path from sleep quality to perceived stress through rumination was significant, and the variance accounted for indicated that 42.2% of the relevant effect was transmitted through the mediator. Because both the direct and indirect pathways remained significant, the mediation was partial rather than complete. This result suggests that poor sleep may increase perceived stress through more than one mechanism, one of which is increased rumination. The finding is strongly aligned with research demonstrating that repetitive cognition acts as an intermediary between stress-related variables and sleep outcomes. Zagaria and colleagues found that perseverative cognition significantly mediated the association between perceived stress and sleep disturbance in their meta-analytic structural equation model (5). Zhang and colleagues similarly reported multiple mediating effects of rumination and social anxiety in the relationship between stress and sleep quality (4). Although these prior investigations primarily modeled stress as an antecedent of sleep disturbance, the present study suggests that the same network may operate in the opposite direction: poor sleep may heighten repetitive negative thinking, which subsequently contributes to greater perceived stress.

The mediating role of rumination is also compatible with findings from occupational and clinical contexts. Mahmoudi and Karimian examined rumination as a mediator in the relationships among occupational stress, chronic fatigue, and sleep quality among female prehospital emergency staff and demonstrated the importance of rumination as a mechanism connecting sustained stress-related demands with sleep-related functioning (12). This finding is relevant to patients with chronic pain because both populations are exposed to persistent stressors and fatigue that may increase cognitive perseveration. The present results also converge with intervention studies suggesting that changes in rumination may occur alongside improvements in sleep and psychological functioning. Wang and colleagues found that acceptance and commitment therapy affected nurses' sleep, rumination, and psychological flexibility, providing evidence

that these processes are therapeutically modifiable and interconnected (13). Similarly, mindfulness-based cognitive therapy has been shown to improve sleep quality and reduce rumination among women with irritable bowel syndrome (3). Such evidence supports the interpretation that rumination is not merely a statistical correlate but may be a clinically meaningful mechanism through which sleep difficulties are translated into greater psychological distress.

The finding of partial rather than complete mediation is particularly important. It suggests that rumination explains a meaningful portion of the association between sleep quality and perceived stress, but other pathways are also likely involved. Poor sleep may affect perceived stress directly through fatigue, reduced emotion regulation, impaired concentration, increased pain sensitivity, and diminished coping capacity. At the same time, it may exert indirect effects through cognitive and affective processes beyond rumination, including worry, catastrophizing, negative affect, or social anxiety. Zhang and colleagues, for example, found that both rumination and social anxiety contributed to the relationship between stress and sleep quality, indicating that multiple psychological pathways may operate simultaneously (4). In chronic pain, additional mechanisms such as fear of pain, pain catastrophizing, experiential avoidance, and reduced psychological flexibility may also be relevant. The fact that the present model explained more than half of the variance in perceived stress demonstrates substantial explanatory power while simultaneously indicating that a considerable proportion of variance remains attributable to factors outside the model.

The present findings also have implications for the broader conceptualization of chronic pain. Chronic pain is increasingly understood as a multidimensional experience in which biological, cognitive, emotional, behavioral, and social factors continuously interact. The current results support this perspective by demonstrating that psychological stress among chronic pain patients is associated not merely with the existence of persistent pain but with processes involving sleep and repetitive cognition. The strong relationship between poor sleep and rumination suggests that nighttime and daytime psychological processes should not be treated as separate domains. Rather, disrupted sleep may influence daytime cognitive regulation, while repetitive negative thought may contribute to sustained stress activation and potentially feed back into subsequent sleep disturbance. Daily research linking rumination with sleep outcomes (11) and studies connecting daily stress rumination with sleep and cortisol regulation (6) reinforce this dynamic perspective. Consequently, chronic pain may be maintained within a reciprocal system in which pain disrupts sleep, poor sleep increases cognitive vulnerability, rumination intensifies perceived stress, and elevated stress may in turn exacerbate pain and further disturb sleep.

The results additionally support the clinical relevance of targeting transdiagnostic cognitive processes in chronic pain management. The conceptualization of repetitive negative thinking as a transdiagnostic mechanism suggests that interventions aimed at reducing rumination may produce benefits across several domains rather than affecting only one symptom category (7). Evidence that acceptance and commitment therapy can influence sleep, rumination, and psychological flexibility (13) and that mindfulness-based cognitive therapy can improve both sleep quality and rumination (3) provides practical support for this possibility. In patients with chronic pain, targeting rumination may reduce the degree to which sleep problems are cognitively amplified into broader perceptions of uncontrollability and psychological burden. At the same time, interventions aimed at improving sleep may indirectly reduce stress by increasing the cognitive resources available for disengaging from repetitive negative thought. The current mediation model

therefore supports an integrated treatment perspective in which sleep and cognitive-emotional processes are addressed together rather than treated as unrelated clinical concerns.

One limitation of the present study is its cross-sectional correlational design, which limits the ability to establish definitive temporal or causal relationships among sleep quality, rumination, and perceived stress. Although the structural model was theoretically specified with sleep quality as the predictor, rumination as the mediator, and perceived stress as the outcome, reciprocal relationships among these variables are plausible. The use of purposive sampling from pain clinics and physiotherapy centers in western Tehran may also limit the generalizability of the findings to patients receiving treatment in other geographical regions, healthcare settings, or community populations. In addition, all principal study variables were measured using self-report questionnaires, which may increase the possibility of common-method variance, recall bias, and socially desirable responding. The study did not differentiate participants according to the specific etiology, anatomical location, intensity, or duration of chronic pain, and potentially relevant variables such as medication use, psychiatric symptoms, pain catastrophizing, socioeconomic status, and comorbid medical conditions were not included in the model. Finally, objective indicators of sleep, such as actigraphy or polysomnography, were not used, and therefore the findings reflect participants' subjective perceptions of sleep quality.

Future research should examine the proposed relationships using longitudinal and prospective designs to clarify the temporal ordering of sleep disturbance, rumination, and perceived stress and to determine whether changes in one variable predict subsequent changes in the others. Experimental and intervention studies could also test whether improving sleep quality or reducing rumination produces measurable reductions in perceived stress among patients with chronic pain. Future investigations should recruit larger and more diverse samples from multiple clinical centers and geographical regions and examine whether the model differs according to sex, age, type of chronic pain, pain severity, pain duration, or treatment status. Combining self-report measures with objective sleep assessments, physiological markers of stress, and ecological momentary assessment could provide a more comprehensive understanding of the mechanisms involved. Researchers may also expand the present model by including potentially relevant mediators or moderators such as pain catastrophizing, worry, psychological flexibility, emotion regulation, perceived social support, depression, anxiety, or coping style and by testing reciprocal or longitudinal structural models to determine whether sleep disturbance and perceived stress form a self-reinforcing cycle through repetitive negative thinking.

From a practical perspective, the findings suggest that psychological and multidisciplinary assessment of patients with chronic pain should routinely include evaluation of sleep quality, perceived stress, and repetitive negative thinking. Clinicians may benefit from identifying patients who simultaneously experience substantial sleep disturbance and high levels of rumination because this combination may indicate increased vulnerability to psychological stress. Interventions for chronic pain could integrate sleep-hygiene education, cognitive and behavioral strategies for improving sleep, techniques for reducing repetitive negative thinking, mindfulness-based exercises, cognitive defusion, attentional shifting, and stress-management skills. Pain clinics and physiotherapy centers may also consider interdisciplinary collaboration between physicians, psychologists, nurses, and rehabilitation specialists to address sleep and cognitive-emotional factors alongside pain symptoms. Early identification and intervention targeting poor sleep and rumination may

help reduce psychological burden, improve coping capacity, and support more comprehensive management of chronic pain.

Acknowledgments

The authors express their deep gratitude to all participants who contributed to this study.

Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

Funding

This research was carried out independently with personal funding and without the financial support of any governmental or private institution or organization.

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