Psychological stress and depression symptoms in nursing undergraduates: the chain mediating effect of cognitive reappraisal and ruminate thinking

Yinjuan Zhang[1,2], Fang Liu[2], Jin Ma[3], Jing Wu[1], Chao Shen[4], Fengjiao Chang[2], Wendong Hu[3*] and Hongjuan Lang[1*]

Abstract

Background Nursing students exhibit a higher incidence of mental disorders. Studies have identified psychological stress contributes to elevated depression symptoms through reappraisal cognitive in nursing students. However, there is little research exploring the knowledge regarding the role of ruminative thinking in mediating the associations between psychological stress and depression symptoms. Guiding by the non-hemostatic model and cognitive control theory, the study aims to investigate the chained mediation of cognitive reappraisal and ruminate thinking between psychological stress and depression symptoms among nursing undergraduates.

Methods A total of 1,220 nursing undergraduates were carried out by stratified sampling from July to December of 2023 via online survey. The investigation adopted the Perceived Stress Scale (PSS-10), Emotion Regulation Questionnaire (ERQ), Ruminative Response Scale (RRS), and the Center for Epidemiologic Studies Depression Scale (CES-D) to measure the level of psychological stress, cognitive reappraisal, ruminative thinking and depression symptoms, respectively. Pearson's r was utilized to investigate the interrelationships, and the structural equation model (SEM) was used to clarify the mediation effects among the four variables.

Results The mean total score of CES-D was 21.57 ± 10.79. SEM analysis proved that psychological stress had a direct positive effect on depression symptoms ($\beta = 0.388$). accounting for a substantial 51.52% of the total effect. Cognitive reappraisal and ruminate thinking partially mediated the association between psychological stress and depression symptoms (95% CI: 0.094–0.210), and the mediating effect accounted for 48.48% of the total effect.

Conclusions Nursing students exhibited a high prevalence of depression, and cognitive reappraisal and ruminate thinking partially mediated the correlations between psychological stress and depression symptoms. Interventions targeting at consolidating cognitive reappraisal and ruminate thinking are imperative for improving depression.

Keywords Cognitive reappraisal, Depression symptoms, Psychological stress, Ruminate thinking

*Correspondence:
Wendong Hu
Huwend@fmmu.edu.cn
Hongjuan Lang
langhj@fmmu.edu.cn
[1]Department of Nursing, Air Force Medical University, No. 169 Changle West Road, Xi'an, Shaanxi 710032, China

[2]Department of Nursing, Shaanxi University of Chinese Medicine, Shiji Avenue, Xianyang, Shaanxi 712046, China
[3]Department of Aerospace Medicine, Air Force Medical University, No. 169 Changle West Road, Xi'an, Shaanxi 710032, China
[4]Department of Computer Science and Engineering, Xi'an Technological University, No. 4 Jinhua North Road, Xi'an, Shaanxi 710021, China

Introduction

Recent reports by the World Health Organization have highlighted a concerning trend: approximately 14% of adolescents globally are affected by mental disorders, with depression being a predominant cause of illness and disability among this population [1]. This issue is particularly pronounced within higher education environments, where the prevalence of depression is escalating alarmingly to 17.3% among college students [2], thus posing a formidable challenge to these institutions [3]. Academic literature increasingly acknowledges depression as a significant barrier to academic achievement within university settings [4, 5]. Systematic reviews indicate that college students, especially those pursuing medical studies, exhibit a higher incidence of depression symptoms when compared to their non-collegiate counterparts or the general population [6, 7]. Moreover, this trend is particularly evident among nursing students, who are more susceptible to depression due to the range of stressors encountered during their college careers [8, 9].

The correlation between gender and the prevalence of depression in college students has been extensively researched. Studies demonstrate that female students, who predominantly make up the nursing profession, are more likely to experience depression symptoms in comparison to their male counterparts [10, 11]. Tung et al. [12] identified that approximately 34.0% of nursing students globally suffer from depression. The consequences of depression on students are profound, affecting their physical health, academic performance, career prospects, and overall well-being [13]. In severe cases, depression can escalate to suicide [14], which has been the second leading cause of death among individuals aged 15 to 34 in the United States, according to the National Institute of Mental Health [15]. *Therefore*, these alarming statistics underscore the urgent need for mental health interventions targeted at mitigating depression symptoms in nursing students.

Cross-national studies have identified psychological stress as a significant predictor of depression [16, 17]. According to the non-homeostatic model of stress, individuals who experience longer, stronger stress are more likely to get into non-homeostatic states of mental and body, such as negative emotional experiences [18], which in turn leads to depression [19]. The nursing profession is frequently cited as one of the most stressful occupations [20], with nursing students experiencing substantial stress and workload, as a result of both their rigorous curriculum and the anticipated demands of their future profession [21, 22]. Nebhinani et al. [23] identify four primary stressors for nursing students: academic and clinical concerns, personal issues, and interfacing student worries. Thus, delineating the link between psychological distress and depression symptoms in nursing undergraduates is imperative for developing effective strategies to alleviate these symptoms.

While it is acknowledged that psychological stress contributes to elevated depression symptoms, the degree of these symptoms varies amongst individuals experiencing distress. This variance is often attributed to differences in cognitive process factors (i.e., emotion regulation, ruminate thinking) [24, 25], which influence individual reactions to stress, leading to diverse outcomes. The current perspectives on depression emphasize the significance of unique cognitive processes and content in sustaining and intensifying depression in the face of psychological stress [26, 27]. Moreover, recent research has a need for checking cognitive variables as potential mechanisms connecting stress and mental health issues [28], which underscores the importance of integrating individual variations into our comprehension of depression.

Emotion regulation provides a powerful and practical approach toward modifying cognitive processes for depression [29]. A substantial body of research indicates that various emotion regulation strategies, particularly in stressful situations, are correlated with depression symptoms among university students [30, 31]. Notably, the maladaptive emotion regulation method is a critical factor in the onset of depression [32]. Emotion regulation involves a broad spectrum of strategies. Antecedent-focused strategies like cognitive reappraisal and response-focused strategies such as expressive suppression have been most studied [33]. Cognitive control theory suggests individuals can moderate the association between risk factors and existing or ongoing emotional responses by changing their recognition. For example, re-understanding the meaning of stimulus by a series of positive and optimistic strategies [34]. Cognitive reappraisal, considered a positive and effective emotion regulation strategy, involves reinterpreting past emotional experiences in a more positive light, thereby altering one's emotional response to them [35]. Research suggests that cognitive reappraisal is effective for managing stress-related mental and physical responses, which can be counterproductive [36, 37]. On the contrary, less frequent use of cognitive reappraisal has been associated with increased depression symptoms [38].

Rumination refers to a well-established cognitive factor for depression symptoms [39], which is another important mechanism to assess when considering intervention factors that might explain the relationship between psychological stress and depression symptoms. Rumination thinking is defined as repetitive and passive on the causes and potential negative outcomes of adverse experiences, instead of taking actions or looking for solutions for their problems [40]. The stress process model asserts that primary stressors in daily routine can exert adverse outcomes by promoting secondary stimuli due to stress

proliferation. The secondary stimulus may be adverse experiences or impaired personal resources (i.e., rumination), which are often seen as indirect effects in the link between the primary stressors and the subsequent outcomes [41]. A wealth of evidence has identified a potential role of rumination thinking as a strengthening factor for depression symptoms [42–44]. Cross-sectional research also reported that rumination played a major function in perceived stress and psychological health [45, 46]. Overall, ruminative thinking maybe a secondary stressor caused by the primary stimulus of psychological stress, which aggravates depression symptoms in college students.

Although the association between psychological stress and depression symptoms is established, the extant literature documents the effect of emotion regulation (i.e., cognitive reappraisal) linking environmental factors to mental health [47, 48]. One recent study reported that rumination moderates the relation between stress and mental health, and the protective function of cognitive reappraisal [49]. Whether cognitive reappraisal can mitigate depression symptoms through rumination is unknown. Given the importance of preparing future nurses, understanding the key role of cognitive reappraisal and rumination is crucial [50, 51]. To address the knowledge gaps, our study aims to explore the relationship between psychological stress, cognitive reappraisal, ruminate thinking, and depression symptoms in nursing undergraduates, to provide practical instruction for nursing students' mental intervention.

The study proposes three hypotheses (Fig. 1):

H1 Cognitive reappraisal of nursing undergraduates mediates the association between psychological stress and depression symptoms;

H2 Ruminate thinking of nursing undergraduates mediates the association between psychological stress and depression symptoms;

H3 Psychological stress of nursing undergraduates affects depression symptoms through the chain mediation of cognitive reappraisal and ruminate thinking.
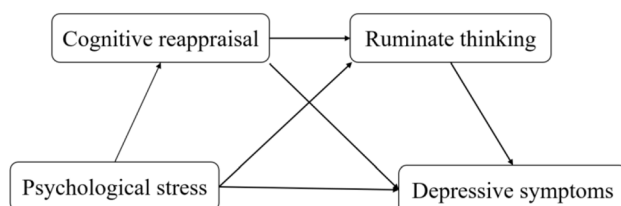

Fig. 1 Conceptual model

Methods

Study design

This study was a cross-sectional design and mediation analysis, and was implemented with the STROBE checklist (Supplementary material 1).

Participants

In the context of this cross-sectional investigation, data acquisition was conducted from July through December 2023, utilizing the professional survey platform, Questionnaire Star. The participants comprise undergraduate nursing students, ranging from first-year students to those in their final year. Nursing students were recruited from four colleges, including Xi'an Jiao Tong University, Air Forth Medical University, Shaanxi University of Chinese Medicine, and Xian Medical College, which were conducted by stratified sampling method. Firstly, a two-stage stratified sampling with the ranking of colleges (e.g., "985 projects" college, "211 projects" college and general college) and grade of students (e.g., freshman, sophomore, junior and senior) was conducted. Secondly, we randomized selected 50% of classes from each grade. Finally, cluster sampling was applied in each class.

The criteria for participant inclusion were stringently defined. Eligible participants were required to be a minimum of 18 years of age, actively enrolled in an undergraduate nursing program at a recognized university, and willing to provide informed consent for participation in the study. Conversely, participants with mental diseases were excluded to ensure the integrity of the study's outcomes, which were screened through professional interviews and the Center for Epidemiologic Studies Depression Scale (CES-D).

In determining a sample size that would be sufficient for the study's needs, adherence was made to the sample size guidelines posited by Kline [52]. These guidelines suggest a sample size ranging from 10 to 20 times the quantity of items within the search and a potential attrition rate of 15%. Consequently, it was resolved that the survey should target a size of nursing students from 667 to 1334.

Data collection

In preparation for the principal research endeavor, an initial survey was executed with the aim of refining the quality of the questionnaire and honing the methods for field testing. This preliminary survey was disseminated through the medium of WeChat groups, encompassing various classes, via a digital link facilitated by the Questionnaire Star. Participants in the survey were entirely voluntary, with students completing the questionnaire using their mobile devices.

Prior to the commencement of the survey, the student participants were thoroughly briefed on the overarching

objectives of the study as well as the specific content of the questionnaire. A prerequisite for participation was the provision of electronic informed consent by the students, affirming their understanding and agreement to partake in the study. Additionally, they were apprised of their right to withdraw from the survey at any juncture should they choose to do so. In order to ensure the effectiveness of the online survey, we checked the answers of all the participants and deleted questionnaires with missing items. Besides, the participants would get a random lucky money to thank for their participation.

The survey yielded a comprehensive dataset, with participation from a total of 1235 nursing students. Out of these, 1220 respondents submitted questionnaires that were deemed valid and thus were included in the subsequent data analysis. This substantial response rate afforded a robust dataset for the study, thereby enhancing the reliability and validity of the research findings.

Measurements
Psychological stress
Nursing undergraduates' stress levels in the study were assessed using the 10-item of the Chinese version of the Perceived Stress Scale (PSS-10), which was translated by Dr. Wang [53], and has been validated among Chinese populations [54]. PSS-10 is divided into two subscales including loss of control (5-item) and sense of tension (5-item), utilizing a 5-point Likert scale for responses, where 1 indicates 'an absence of stress' and 5 indicates 'severe stress'. The scale's validity is supported by Cronbach's alpha, often exceeding 0.70, denoting strong internal consistency [55]. Specifically, for this study, a Cronbach's alpha of 0.866 confirms the PSS-10 as a robust tool for evaluating stress in nursing students.

Cognitive reappraisal
The subscale of the Chinese version of Emotion Regulation Questionnaire (ERQ) was used to measure the ability of cognitive reappraisal, which was translated by Wang and his colleagues, and has been validated [56]. ERQ consists of two subscales: cognitive reappraisal (6-item) and expressive suppression (4-item). The ERQ responses are captured on a 7-point Likert scale, where 1 indicates 'strongly disagree' and 7 indicates 'strongly agree'. Elevated scores on a subscale imply a more pronounced propensity towards employing the respective emotion regulation strategy. In this investigation, the focus was directed toward the cognitive reappraisal subscale to ascertain the undergraduates' adeptness in employing this particular strategy. The ERQ's reliability, especially the cognitive reappraisal subscale, was evidenced in this study with a Cronbach's alpha of 0.820.

Ruminate thinking
To quantify the ruminate thinking among nursing undergraduates, the Chinese version of the Ruminative Response Scale (RRS-22) was employed. The Chinese RRS serves as a reliable and valid tool in the Chinese population [57], which is divided into three subscales encompassing symptom rumination (12-item), brooding (5-item), and reflective pondering (5-item). Responses are articulated on a 7-point Likert scale, where 1 indicates 'very untrue of me' and 7 indicates 'very true of me'. Higher scores on this scale suggest increased levels of rumination. The RRS is acknowledged for its satisfactory convergent validity [58]. The current study reported a Cronbach's alpha for the RRS at 0.799.

Depression symptoms
Depression symptoms in this study were gauged using the 20-item Chinese version of the Center for Epidemiologic Studies Depression Scale (CES-D), which has been adopted in Chinese literature [59, 60]. CES-D encompasses various aspects of depression, including mood, guilt, worthlessness, helplessness, psychomotor aspects, appetite, and sleep disturbances. The scale employs a 4-point Likert scale, where 0 indicates 'very untrue of me' and 3 indicates 'very true of me', with higher scores indicative of more pronounced depression symptoms. The CES-D is lauded for its exceptional psychometric properties and is widely utilized in psychiatric epidemiology [61]. Its high internal consistency has been documented across various studies in multiple languages [62]. In the present study, the CES-D demonstrated a Cronbach's alpha of 0.799.

Statistical analysis
The statistical analysis encompassed the use of IBM SPSS 25.0 for descriptive data analysis and Amos 28.0 for the construction and verification of structural equation modeling (SEM). T-tests and one-way ANOVA were employed to scrutinize differences across multiple groups. Pearson correlation analysis was utilized to investigate the interrelationships among psychological stress, cognitive reappraisal, rumination, and depression symptoms. Subsequent to these correlations, a structural equation model was formulated and verified using Amos 28.0, incorporating a bootstrap methodology (executed 1000 times) for the assessment of mediation effects (95%CI, $P < 0.05$). The model's fitness was evaluated employing various indices, including chi-square ($\chi 2$), degrees of freedom (DF), chi-square/degree of freedom ratio ($\chi 2$/DF), root mean square error of approximation (RMSEA), the adjusted goodness-of-fit index (AGFI), the incremental fit index (IFI), Tucker Lewis index (TLI), and the comparative fit index (CFI). A P-value of less than

Table 1 Description and univariate analysis of depressive symptoms among nursing students (*N* = 1220)

Variable	*N* (%)	Depressive symptoms M(SD)	t/F	*P*
Total	1220(100)	21.57(10.79)		
Gender			-1.746[a]	0.079
Male	96(7.8)	20.36(10.56)		
Female	1124(92.2)	21.46(11.25)		
Grade			1.068[b]	0.324
Freshmen	340(27.9)	21.56(11.23)		
Sophomore	320(26.2)	20.48(11.08)		
Junior	296(24.2)	19.87(10.45)		
Senior	264(21.7)	22.95(11.36)		
Resident location			1.569[a]	0.103
Urban	562(46.1)	21.04(10.74)		
Rural	658(53.9)	21.87(11.26)		
Chronic disease			2.856[a]	0.024
Yes	28(2.3)	23.22(12.85)		
No	1192(97.7)	20.13(10.13)		
Interest in nursing			-2.311[a]	0.033
Yes	708(58.0)	19.45(10.33)		
No	512(42.0)	23.39(9.78)		

Note: [a] = t-test. [b] = ANOVA

0.05 was deemed statistically significant in this analytical process.

Ethical considerations

The ethical considerations of the study were meticulously upheld, as evidenced by the approval granted by the Ethics Committee of the Second Affiliated Hospital of Shaanxi University of Chinese Medicine (No. SZFYIEC-YJ-2020-38). The survey was meticulously designed to ensure the utmost protection of participant privacy. To this end, all responses were collected anonymously, no personal information of the participants was solicited, and all data submitted were treated with the strictest confidentiality.

Results

Demographic characteristic

Within the scope of this investigation, the cohort comprised 1,220 nursing students. The average total score of depression symptoms was 21.57 (SD = 10.79), which implied the prevalence of clinical depression achieved 65.2% among Chinese nursing students by using the criteria of 16 or greater. 92.2% of students are females (*n* = 1124). The mean age was 21.37 years (SD = 10.26), and the demographic distribution further indicated that half of the students originated from rural areas. Regarding their inclination towards the nursing profession, 58% of the participants reported a preference for nursing as a career path (*n* = 708). Notably, a minor segment of the sample, constituting 2.3% (*n* = 28), disclosed the presence of chronic diseases.

The investigation yielded statistically significant variations in the manifestation of depression symptoms when stratified according to the presence of chronic illnesses and the degree of career interest in nursing. The comprehensive elucidation and analysis of these disparities were delineated in Table 1 of the study.

The relationships between psychological stress, cognitive reappraisal, ruminate thinking and depression symptoms

The data, as expounded in Table 2, demonstrate significant correlations between psychological stress, cognitive reappraisal, ruminate thinking, and depression symptoms within the nursing student demographic. Specifically, a negative correlation between psychological stress and cognitive reappraisal ($r = -0.264$, $p < 0.01$). Psychological stress also exhibited a positive correlation with ruminate thinking ($r = 0.397$, $p < 0.01$). An inverse relationship was observed between cognitive reappraisal and ruminate thinking ($r = -0.395$, $p < 0.01$), as well as between cognitive reappraisal and depression symptoms ($r = -0.469$, $p < 0.01$). Ruminate thinking and psychological stress were positively correlated with depression symptoms ($r = 0.548$, $p < 0.01$; $r = 0.366$, $p < 0.01$).

Table 2 Correlation analysis between psychological stress, cognitive reappraisal, ruminate thinking and depressive symptoms of the participants (*N* = 1220)

	Variables	M(SD)	1	2	3	4	5	6	7	8	9
1	**Cognitive reappraisal**	26.47(11.46)	1.000								
2	**Psychological stress**	24.59(7.89)	− 0.264**	1.000							
3	Loss of control	10.01(3.35)	− 0.226**	0.826**	1.000						
4	Sense of tension	14.58(4.56)	− 0.217**	0.852**	0.408**	1.000					
5	**Depressive symptoms**	21.57(10.79)	− 0.469**	0.366**	0.229**	0.380**	1.000				
6	**Ruminate thinking**	45.05(10.36)	− 0.395**	0.397**	0.295**	0.369**	0.548**	1.000			
7	Symptom rumination	23.56(6.30)	− 0.355**	0.359**	0.251**	0.349**	0.444**	0.574**	1.000		
8	Brooding	11.08(3.12)	− 0.087*	0.092*	0.097*	0.105**	0.172**	0.517**	0.097*	1.000	
9	Reflective pondering	10.41(2.79)	− 0.277**	0.208**	0.206**	0.146**	0.288**	0.536**	0.232**	0.082*	1.000

Note: **$p < 0.01$. *$P < 0.05$

Table 3 Fitness indexes of the structural equation model

Index	χ^2	DF	χ^2/DF	RMSEA	AGFI	IFI	TLI	CFI
Criteria	-	-	1–3	< 0.08	> 0.8	> 0.9	> 0.9	> 0.9
Actual value	3349.272	1471	2.277	0.042	0.977	0.977	0.954	0.923
Decision			Good fitting					

Note χ2 = chi-square, DF = degrees of freedom, RMSEA = root mean square error of approximation, AGFI = the adjusted goodness-of-fit index, IFI = the incremental fit index, Tucker Lewis index (TLI), CFI = the comparative fit index
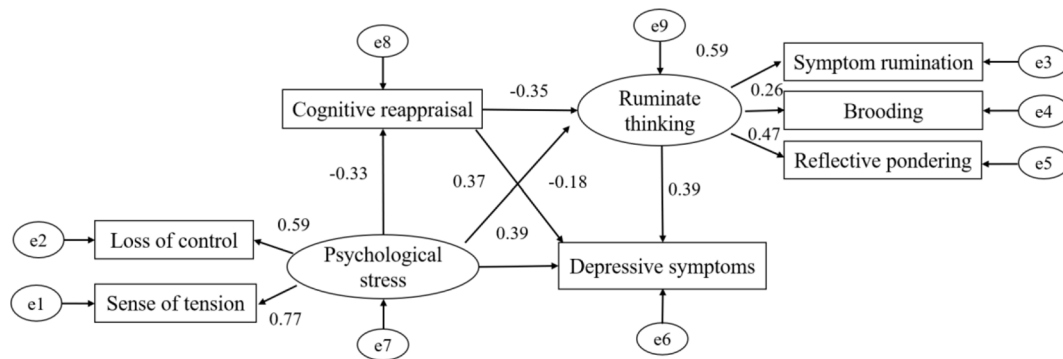
Fig. 2 A multiple mediation model of cognitive reappraisal and ruminate thinking mediating psychological distress and depressive symptoms

Table 4 The standardized total, direct, and indirect effects of psychological stress on depressive symptoms with cognitive appraisal and ruminate thinking

Model Pathway	β	SE	95%CI		Percent (%)
			Lower	Upper	
Total effect	0.639	0.076	0.601	0.894	100
Direct effect	0.388	0.086	0.226	0.563	51.52
Psychological stress → Depressive symptoms					
Indirect effect	0.251	0.029	0.094	0.210	48.48
Psychological stress →Cognitive reappraisal→ Depressive symptoms	0.146				28.18
Psychological stress →Ruminate thinking→ Depressive symptoms	0.060				11.54
Psychological stress →Cognitive reappraisal →Ruminate thinking→ Depressive symptoms	0.045				8.76

Mediating effect tests

The results presented in Table 3 of the study elucidate the fitness indices of the proposed hypothetical model. These indices manifest a commendable fit of the model to the empirical data, as indicated by the following metrics: χ2 = 3349.272, χ2/DF = 2.277, RMSEA = 0.042, AGFI = 0.977, IFI = 0.977, TFI = 0.954, and CFI = 0.923. The congruence of these indices with the hypothesized model underscores its robust alignment with the gathered empirical data.

Figure 2 and the accompanying Table 4 delineate the outcomes of the mediation model, specifically concentrating on the influence of psychological stress on depression symptoms among nursing students. This comprehensive analysis segregates the effects into total, direct, and indirect categories, with the 95% confidence interval (CI) of the indirect path coefficient underscoring the existence of a mediation effect. A prominent direct effect (0.388) of psychological stress on depression symptoms was observed, accounting for a substantial 51.52% of the total effect. The mediating role of cognitive reappraisal in the nexus between psychological stress and depression symptoms emerged as significant. The effect value in this context was 0.146, translating to 28.18% of the total effect. Besides, the mediating effect of ruminate thinking in the psychological stress-depression symptoms dynamic yielded an effect value of 0.06, representing 11.54% of the total effect. The cumulative mediating effect of both cognitive reappraisal and ruminate thinking was calculated at an effect value of 0.045, which constitutes 8.76% of the total effect. In summation, the aggregate mediating effect, encompassing cognitive reappraisal, ruminate thinking, and their combined influence, accounts for 48.48% of the total effect of psychological stress on depression symptoms.

Discussion

This study rigorously examines the pressing issue of depression among nursing undergraduates, a demographic of growing concern to educational agencies. It focuses on Chinese nursing undergraduates, exploring the prevalence of depression symptoms and delineating

the complex interrelationships among perceived stress, cognitive reappraisal, ruminate thinking, and depression symptoms through a nuanced chained mediation modeling analysis. The findings proffer significant insights into the mechanisms that bridge perceived stress and depression symptoms, thereby offering novel perspectives for the development of effective interventions and prevention programs targeting this specific population.

The research unveils a disconcerting statistic: the average score for depression symptoms among the nursing students stood at 21.57(SD = 10.79), indicating that 65.2% had a risk of clinical depression, which was in congruent with the prior study conducted in Thailand [63]. Other studies also documented a heightened prevalence of depression symptoms in nursing undergraduates [64, 65]. The etiology of this elevated risk profile is multifactorial, with the inherently stressful nature of the nursing profession, characterized by its rigorous academic curriculum and substantial professional performance pressures, emerging as a principal contributor [23, 66]. For instance, nursing students in Korea must complete over 1,000 h of clinical practice in their penultimate and final academic years [67]. Further, nursing students frequently confront dilemmas regarding their chosen profession, grappling with issues such as lower social status relative to medical counterparts and insufficient respect from patients and society, thereby perpetuating a longstanding effort-reward imbalance [68, 69]. Additionally, experiences of workplace violence in hospital settings can attenuate their enthusiasm, engendering value conflicts between their intrinsic beliefs and the realities of their profession [70]. These findings underscore the necessity for a comprehensive reassessment of nursing education methodologies.

A pivotal discovery of this research is the mediating influence of cognitive reappraisal in the relationship between psychological stress and depression symptoms. This supports the hypothesis that augmenting the utilization of cognitive reappraisal can attenuate the adverse impact of psychological stress on depression [28]. In our study, cognitive reappraisal occupies a consequential role in modulating the impact of psychological stress on depression symptoms. Cognitive reappraisal serves as a protective mechanism, aiding individuals in managing the ramifications of stress, enhancing adaptability in high-pressure contexts, and diminishing the emergence of negative emotions such as depression [71]. Besides, previous research posits that cognitive reappraisal intervenes early in the emotion generation process, preempting the emotional response tendency and promoting sympathetic nervous system activity, thereby aiding individuals in adapting to environmental changes [72]. Consequently, individual adept in cognitive reappraisal can effectively mitigate and truncate stress cycles, reducing

their susceptibility to depression symptoms [73]. The findings of this study corroborate the utility and adaptability of cognitive reappraisal strategies in mediating the perception of stress and depression among nursing students, underscoring its potential as an integral element in mental health interventions for this group.

Moreover, the study elucidates the mediating role of ruminate thinking in the relationship between psychological stress and depression symptoms. This is in alignment with existing literature that identifies rumination as a mediator between negative life events and depression [74]. This finding supports the stress process model, which depicts that preliminary stressors may cause adverse outcomes through secondary stimuli that facilitate negative experiences [41]. For nursing graduates, high academic pressure and stressful job demands (preliminary stressor) may lead to negative emotions and suppressed physical and mental recovery, even damaging sleep quality, which causes ruminate thinking (secondary stressor) during resting time [75]. Thus, ruminate thinking transfers the adverse effect of psychological stress into the mental health outcomes of nursing students. Historically, rumination has been central to depression research, particularly in studies involving depression samples [76, 77]. This study contributes to the broader discourse by positing that rumination, as a cognitive process, not only is pertinent to depressive samples but also mediates the relationship between psychological stress and depression symptoms in nursing undergraduates.

An additional critical insight derived from this research is the chained mediation mechanism, where the relation between psychological stress and depression symptoms was mediated by both cognitive reappraisal and ruminate thinking. The finding is consistent with another study, which clarified that college students who tended to cognitively reappraise are less likely to show a high level of ruminate thinking when facing stressful events, such as COVID-19 [78]. when they haven't repeated negative thoughts about stressors, they will utter their feelings appropriately, and thus experience cumulative effects of the positive emotions on health consequences of college students [79]. The underlying mechanism suggests that cognitive reappraisal modifies an individual's cognition, altering the semantic representation of emotional information, which results in decreased amygdala activity and heightened cognitive control activity in the frontal lobe [80]. While studies indicate that individuals prone to rumination typically exhibit lower levels of self-control and self-regulation [81]. Furthermore, cognitive reappraisal assists individuals in reinterpreting stressful events in a less threatening light, thereby curtailing the propensity for rumination, often linked with prolonged negative affect and an increased risk of depression [82]. Therefore, cognitive reappraisal strategies can reduce

individuals' repetitive contemplation of negative emotions, reframe their perception of negative information or emotions, and reduce their rumination thinking. This insight implies that interventions focusing on enhancing cognitive reappraisal skills could effectively reduce both rumination and depression symptoms, particularly in high-stress environments such as those encountered by nursing undergraduates. Recent research has found that working memory training (WMT) could improve the ability of cognitive reappraisal of participants by using the late positive potential (LPP) [83, 84], which may alleviate the intensity of rumination and depression symptoms in nursing undergraduates.

Limitations
In this study, there are some limitations. First, the study's reliance on a cross-sectional framework necessitates caution in the interpretation of its findings. This methodological choice allows for the identification of associations and correlations at a singular temporal juncture. However, it inherently precludes the establishment of definitive causal inferences, thereby limiting the capacity to discern cause-and-effect dynamics. Second, the exclusive focus on nursing students from a solitary province in Northwest China imposes constraints on the representativeness and extrapolative potential of the study's outcomes. The experiences and responses of nursing students within this distinct geographical locale may not accurately mirror or encapsulate the experiences of their counterparts in disparate regions or nations, thereby restricting the generalizability of the findings. Third, the study's reliance on self-reported data introduces an element of potential bias, particularly recall bias. The accuracy and veracity of participant responses may be subject to influence by their prevailing mood states, memory recall, and personal perceptions, which could, in turn, impact the reliability and fidelity of the collected data.

Conclusion
The mental well-being of nursing students has a direct bearing on the prospective reservoir of eligible nurse teams in the future, and even the development of high-quality nursing. Therefore, it is critical to target interventions for relieving the mental health of nursing students. Nursing students show a high prevalence of depression symptoms. The psychological stress has a positive effect on the depression. Furthermore, cognitive reappraisal and ruminate thinking exhibited a chain meditating effect between psychological stress and depression symptoms. Interventions targeting cognitive reappraisal and ruminative thinking will be efficacious in improving depression symptoms among nursing students. Additionally, it is crucial to actively promote nursing students' understanding the stress from a positive perspective in daily life and study.

Recommendations
In light of these findings, future interventions designed to alleviate depression among nursing undergraduates should prioritize the enhancement of cognitive reappraisal skills and the modification of rumination patterns for nurse educators and managers. Enhancing cognitive reappraisal could encompass training that enables students to reinterpret and reframe stressful scenarios in a more positive or less menacing perspective, thereby diminishing the emotional toll of such situations. Concurrently, addressing rumination might involve strategies aimed at diverting focus from persistent negative cogitation towards more constructive, solution-oriented thought processes. Furthermore, such interventions could be seamlessly integrated into nursing curricula or offered as adjunct workshops or counseling services for nursing students in colleges or hospitals.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12912-024-02604-6.

Supplementary Material 1

Data availability
The data that supported this research was available and can be obtained by from the corresponding authors. For the protection of privacy and ethics restriction, the data cannot be public available.

Declarations

Ethics approval and consent to participate
The study adhered to the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the Second Affiliated Hospital of Shaanxi University of Chinese Medicine (No. SZFYIEC-YJ-2020-38). The questionnaire was completed online in the WeChat application after informed consent was obtained.

Consent for publication
Not applicable.

References
1. World Health Organization. WHO highlights urgent need to transform mental health and mental health care. 2022. [https://www.who.int/news-room/fact-sheets/detail/adolescent-mental-health]
2. Cui Wang H, Chen S, Shang. Association between depression and lung function in college students. Front Public Health. 2023;11:1093935. https://doi.org/10.3389/fpubh.2023.1093935.
3. Dessauvagie AS, Dang HM, Nguyen TAT, Groen G. Mental health of university students in southeastern Asia: A systematic review. Asia Pac J Public Health. 2022;34:172–81. https://doi.org/10.1177/10105395211055545.
4. Jiang Z, Jia X, Tao R, Dordüncü H. COVID-19: a source of stress and depression among university students and poor academic performance. Front Public Health. 2022;10:898556. https://doi.org/10.3389/fpubh.2022.
5. Wagner F, Wagner RG, Kolanisi U, Makuapane LP, Masango M, Gomez-Olive FX. The relationship between depression symptoms and academic performance among first-year undergraduate students at a South African university: a cross-sectional study. BMC Public Health. 2022;22(1):1–9. https://doi.org/10.1186/s12889-022-14517-7.
6. Luo W, Zhong BL, Chiu HFK. Prevalence of depressive symptoms among Chinese university students amid the COVID-19 pandemic: a systematic review and meta-analysis. Epidemiol Psychiatr Sci. 2021;30:e31. https://doi.org/10.1017/S2045796021000202.
7. Zou Q, Tang Y, Jiang C, Lin P, Tian J, Sun S. Prevalence of anxiety, depressive and insomnia symptoms among the different groups of people during COVID-19 pandemic: an overview of systematic reviews and meta-analyses. Front Psychol. 2022;13:1024668. https://doi.org/10.3389/fpsyg.2022.1024668.
8. Ching SSY, Cheung K, Hegney D, Rees CS. Stressors and coping of nursing students in clinical placement: A qualitative study contextualizing their resilience and burnout. Nurse Educ Pract. 2020;42:102690. https://doi.org/10.1016/j.nepr.2019.102690.
9. Zheng YX, Jiao JR, Hao WN. Stress levels of nursing students: a systematic review and meta-analysis. Medicine. 2022;101(36):e30547. https://doi.org/10.1097/MD.0000000000030547.
10. Mofatteh M. 2021. Risk factors associated with stress, anxiety, and depression among university undergraduate students. AIMS Public Health. 2021; 8 (1):36. https://doi.org/10.3934/publichealth.2021004
11. Yu M, Tian F, Cui Q, Wu H. Prevalence and its associated factors of depressive symptoms among Chinese college students during the COVID-19 pandemic. BMC Psychiatry. 2021;21(1):1–8. https://doi.org/10.1186/s12888-021-03066-95.
12. Tung YJ, Lo KK, Ho RC, Tam WSW. Prevalence of depression among nursing students: a systematic review and meta-analysis. Nurse Educ Today. 2018;63:119–29. https://doi.org/10.1016/j.nedt.2018.01.009.
13. Wetherall K, Robb KA, O'Connor RC. Social rank theory of depression: a systematic review of self-perceptions of social rank and their relationship with depressive symptoms and suicide risk. J Affect Disord. 2019;246:300–319. https://doi.org/10.1016/j.jad.2018.12.045.
14. Asfaw H, Yigzaw N, Yohannis Z, Fekadu G, Alemayehu Y. Prevalence and associated factors of suicidal ideation and attempt among undergraduate medical students of Haramaya University, Ethiopia. A cross-sectional study. PLoS ONE. 2020;15(8):e0236398. https://doi.org/10.1371/journal.pone.0236398.
15. National Institute of Mental Health (NIMH). Suicide is a leading cause of death in the United States. 2022. https://www.nimh.nih.gov/health/statistics/suicide
16. Hai NT, Thi HL, Cong T, Thi HT, Thi VTH, Vo LO, Le TT, et al. Investigating Effects of COVID-19 Pandemic on the Mental Health of Nursing Students During Remote Learning: An Experience from Dong A University. Vietnam. 2022;8:23779608221135437. https://doi.org/10.1177/23779608221135437.
17. Klongdee K, Chaniang S. Factors predicting depression in nursing students at Boromarajonani College of Nursing Nakhonphanom. Nakhonphanom Univ J Piloce Nurses. 2021;13(1):148–57. https://he01.tci-thaijo.org/index.php/policenurse/article/view/247485.
18. Russell G, Lightman S. The human stress response. Nat Rev Endocrinol. 2019;15:525–34. https://doi.org/10.1038/s41574-019-0228-0.
19. Li YD, Jiang Q-X, Jiang J, Kuang YL. Analysis of the correlation between mental health status and stress perceptions and coping styles of students from special groups in higher education. Chin Health Educ. 2021;27:228–33. https://doi.org/10.16168/j.cnki.issn.10029982.2021.03.008.
20. Babapour AR, Gahassab-Mozaffari N, Fathnezhad-Kazemi A. Nurses' job stress and its impact on quality of life and caring behaviors: a cross-sectional study. BMC Nurs. 2022;21(1):1–10. https://doi.org/10.1186/s12912-022-00852-y.
21. Hwang E, Kim J. Factors affecting academic burnout of nursing students according to clinical practice experience. BMC Med Educ. 2022;22(1):1–10. https://doi.org/10.1186/s12909-022-03422-7.
22. Thomas LMB. Stress and depression in undergraduate students during the COVID-19 pandemic: Nursing students compared to undergraduate students in nonnursing majors. J Prof Nurs. 2022;38:89–96. https://doi.org/10.1016/j.profnurs.2021.11.013.
23. Nebhinani M, Kumar A, Parihar A, Rani R. Stress and coping strategies among undergraduate nursing students: a descriptive assessment from Western Rajasthan. Indian J Community Med: Off Publ Indian Assoc Prev Soc Med. 2020;45(2):172. https://doi.org/10.4103/ijcm.IJCM_231_19.
24. Hu T, Zhang D, Wang J, Mistry R, Ran G, Wang X. Relation between emotion regulation and mental health: A meta-analysis review. Psychol Rep. 2014;114(2):341–62. https://doi.org/10.2466/03.20.PR0.114k22w4.
25. Zhou HX, Chen X, Shen YQ, Li L, Chen NX, Zhu ZC, et al. Rumination and the default mode network: Meta-analysis of brain imaging studies and implications for depression. NeuroImage. 2020;206:116287. https://doi.org/10.1016/j.neuroimage.2019.116287.
26. Dozois DJA. The importance of social connectedness: From interpersonal schemas in depression to relationship functioning and well-being. Can Psychol. 2021;62(2):174–80. https://doi.org/10.1037/cap0000253.
27. Wilde JL, Dozois DJ. A. A dyadic partner-schema model of relationship distress and depression: Conceptual integration of interpersonal theory and cognitive-behavioral models. Clin Psychol Rev. 2019;70:13–25. https://doi.org/10.1016/j.cpr.2019.03.003.
28. Liu Y, Yu H, Shi Y, Ma C. The effect of perceived stress on depression in college students: The role of emotion regulation and positive psychological capital. Front Psychol. 2023;14:1110798. https://doi.org/10.3389/fpsyg.2023.1110798.
29. Hayes BK, Harikumar A, Ferguson LA, Dicker EE, Denny BT, Leal SL. Emotion regulation during encoding reduces negative and enhances neutral mnemonic discrimination in individuals with depressive symptoms. Neurobiol Learn Mem. 2023;205:107824. https://doi.org/10.1016/j.nlm.2023.107824.
30. Lopes AR, Nihei OK. Depression, anxiety and stress symptoms in Brazilian university students during the COVID-19 pandemic: Predictors and association with life satisfaction, psychological well-being and coping strategies. PLoS ONE. 2021;16(10):e0258493. https://doi.org/10.1371/journal.pone.0258493.
31. Miao Q, Xie L, Xing B, Wang X, Tang S, Luo H. Emotional states and coping methods in nursing and non-nursing students responding to COVID-19: a crosssectional study in China. BMJ Open. 2021;11(8):e054007. https://doi.org/10.1136/bmjopen-2021-054007.
32. Joormann J, Stanton CH. Examining emotion regulation in depression: A review and future directions. Behav Res Ther. 2016;86:35–49. https://doi.org/10.1016/J.BRAT.2016.07.007.
33. Gross JJ. The Emerging Field of Emotion Regulation: An Integrative Review. Rev Gen Psychol. 1998;2:271–99. https://doi.org/10.1037/1089-2680.2.3.271.
34. Ochsner Kevin N, Gross James J. The cognitive control of emotion. Trends Cogn Sci. 2005;9(5):242–9. https://doi.org/10.1016/j.tics.2005.03.010.
35. Gross JJ, John OP. Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. J Personal Soc Psychol. 2003;85(2):348–62. https://doi.org/10.1037/0022-3514.85.2.348.
36. Restubog SLD, Ocampo ACG, Wang L. Taking control amidst the chaos: Emotion regulation during the COVID-19 pandemic. J Vocat Behav. 2020;119:103440. https://doi.org/10.1016/j.jvb.2020.103440.
37. Ferreira S, Pêgo JM, Morgado PA. Systematic Review of Behavioral, Physiological, and Neurobiological Cognitive Regulation Alterations in Obsessive-Compulsive Disorder. Brain Sci. 2020;10:797. https://doi.org/10.3390/brainsci10110797.
38. Dawel A, Shou Y, Gulliver A, Cherbuin N, Banfield M, Murray K, Calear AL, Morse AR, Farrer LM, Smithson M. Cause or symptom? A longitudinal test of bidirectional relationships between emotion regulation strategies and mental health symptoms. Emotion. 2021;21(7):1511–21. https://doi.org/10.1037/emo0001018.
39. Pulopulos MM, Hoorelbeke K, Vandenbroucke S, Durme K, Hooley JM, Raedt R. The interplay between self-esteem, expectancy, cognitive control,

rumination, and the experience of stress: a network analysis. Curr Psychol. 2023;42:15403–11. https://doi.org/10.1007/s12144-022-02840-6.

40. Treynor W, Gonzalez R, Nolen-Hoeksema S. Rumination Reconsidered: A Psychometric Analysis. Cogn Ther Res. 2003;27:247–59. https://doi.org/10.1023/A:1023910315561.

41. Gazzaz AZ, Carpiano RM, Aleksejuniene J. Parenting stress as a mediator in the oral health of children and adolescents: a stress process model. Community Dent Oral Epidemiol. 2020;48(4):288–95. https://doi.org/10.1111/cdoe.12531.

42. Liu D, Wang Y, Xie P, Deng H, Qiu L, Liu W et al. Rumination and Depression in Chinese Adolescents With Mood Disorders: The Mediating Role of Resilience. J Clin Psychiatry. 2023;84(5):22m14682. https://doi.org/10.4088/JCP.22m14682. PMID: 37498649.

43. Wu Q, Cao H, Lin X, Zhou N, Chi P. Child maltreatment and subjective well-being in Chinese emerging adults: a process model involving self-esteem and self-compassion. J Interpers Violence. 2022;37:15–6. https://doi.org/10.1177/0886260521993924.

44. Pehlivan MJ, Sherman KA, Wuthrich V, Horn M, Basson M, Duckworth T. Body image and depression in endometriosis: Examining self-esteem and rumination as mediators. Body Image. 2022;43:463–473. https://doi.org/10.1016/j.bodyim.2022.10.012. Epub 2022 Nov 4. PMID: 36345084.

45. Hong W, Liu RD, Ding Y, Fu X, Zhen R, Sheng X. Social Media Exposure and College Students' Mental Health During the Outbreak of COVID-19: The Mediating Role of Rumination and the Moderating Role of Mindfulness. Cyberpsychol Behav Soc Netw. 2021;24(4):282–7. https://doi.org/10.1089/cyber.2020.0387.

46. Schachter J, Ajayi AA, Nguyen PL. The moderating and mediating roles of mindfulness and rumination on COVID-19 stress and depression: A longitudinal study of young adults. J Couns Psychol. 2022;69(5):732–44. https://doi.org/10.1037/cou0000626. Epub 2022 Jun 23. PMID: 35737540.

47. Sardella A, Varallo G, Agus M, Lenzo V, Zagaria A, Terrone G, et al. Anxiety, depression, emotion regulation, and daytime sleepiness: are there links between these factors? Network analysis on an Italian sample during the COVID-19 pandemic. Clin Neuropsychiatry. 2023;20(5):395–404. https://doi.org/10.36131/cnfioritieditore20230501.

48. Wang Y, Guang Z, Zhang J, Han L, Zhang R, Chen Y, et al. Effect of Sleep Quality on Anxiety and Depression Symptoms among College Students in China's Xizang Region: The Mediating Effect of Cognitive Emotion Regulation. Behav Sci. 2023;13:861. https://doi.org/10.3390/bs13100861.

49. Wu Q, Cao H, Du H, Work Stress W-R, Rumination. Depressive Symptoms in University Teachers: Buffering Effect of Self-Compassion. Psychol Res Behav Manag. 2023;16:1557–69. https://doi.org/10.2147/PRBM.S403744.

50. Querstret D, Cropley M, Kruger P, Heron R. Assessing the effect of a Cognitive Behaviour Therapy (CBT)-based workshop on work-related rumination, fatigue, and sleep. Eur J Work Org Psychol. 2016;25(1):50–67. https://doi.org/10.1080/1359432X.2015.1015516.

51. Patel A, Daros AR, Irwin SH, Lau P, Hope IM, Perkovic SJM, et al. Associations between rumination, depression, and distress tolerance during CBT treatment for depression in a tertiary care setting. J Affect Disord. 2023;15(339):74–81. https://doi.org/10.1016/j.jad.2023.06.063.

52. Kline RB. Principles and Practice of Structural Equation Modeling. New York: The Guilford Press; 2016.

53. Wang Z, Chen J, Boyd JE, Zhang H, Jia X, Qiu J, Xiao Z. Perceived Stress Scale-10–Chinese Version (PSS-10, PSS). APA PsycTests. 2011. https://doi.org/10.1037/t45870-000. Database record.

54. Huang F, Wang H, Wang Z, Zhang J, Du W, Su C, et al. Psychometric properties of the perceived stress scale in a community sample of Chinese. BMC Psychiatry. 2020;20(1):130. https://doi.org/10.1186/s12888-020-02520-4.

55. Lee E. Review of the psychometric evidence of the Perceived Stress Scale. Asian Nurs Res. 2012;6(4):121–7. https://doi.org/10.1016/j.anr.2012.08.004.

56. Wang L, Liu HC, Li ZQ, Du W. Reliability and validity of emotion regulation questionnaire Chinese revised version. Chin J Health Psychol. 2007;15(6):503–5.

57. Han X, Yang HF. Chinese version of Nolen-Hoeksema ruminative responses scale (RRS) used in 912 college Students: Reliability and validity. Chin J Clin Psychol. 2009;17(5):550–1.

58. Nolen-Hoeksema S. Response to depression and their effects on the duration of depressive episodes. J Abnorm Psychol. 1991;100:569–82. https://doi.org/10.1037//0021-843x.100.4.569.

59. Song Y, Liu Z, Chen H, Guo Q, Huang Y. Incidence and Risk Factors of depressive Symptoms in Chinese College Students. Neuropsychiatr Dis Treat.

2020;16:2449–57. https://doi.org/10.2147/NDT.S264775. PMID: 33122908; PMCID: PMC7591009.

60. Jiang L, Wang Y, Zhang Y, Li R, Wu H, Li C, et al. The Reliability and Validity of the Center for Epidemiologic Studies Depression Scale (CES-D) for Chinese University Students. Front Psychiatry. 2019;10:315. https://doi.org/10.3389/fpsyt.2019.00315.

61. Center for Innovative Public Health Research. CESD-R: The Center for Epidemiologic Studies Depression Scale Revised. 2022. https://cesd-r.com

62. Kimong PJ, Erford BT, DeCino DA. Psychometric synthesis of the Center for Epidemiologic Studies Depression Scale-Revised English and translated/adapted versions. Meas Evaluation Couns Dev. 2022;1–17. https://doi.org/10.1080/07481756.2022.2099900.

63. Nway NC, Phetrasuwan S, Putdivarnichapong W, Vongsirimas N. Factors contributing to depressive symptoms among undergraduate nursing students: A cross-sectional study. Nurse Educ Pract. 2023;68:103587. https://doi.org/10.1016/j.nepr.2023.103587.

64. McDermott RC, Fruh SM, Williams S, Hauff C, Sittig S, Wright T, Hall H. Characteristics of negative and positive mental health among nursing students in the United States. J Am Psychiatr Nurses Assoc. 2021;27(1):44–53. https://doi.org/10.1177/1078390319865322.

65. Karseewong wiramon, Kongthanachayopit S. Effects of a mental health promotion and mental health prevention program on stress and depression among first-year nursing students. J Nurs Siam Univ. 2022;23(44):36–48.

66. Zhang Y, Zheng P, Chen D, Niu Q, Pang D, Song A, et al. The association between academic stress, social support, and self-regulatory fatigue among nursing students: a cross-sectional study based on a structural equation modelling approach. BMC Med Educ. 2022;22(1):1–10. https://doi.org/10.1186/s12909-022-03829-2.

67. Shin S, Yang EB, Hwang E, Kim K, Kim Y, Jung D. Current status and future direction of nursing education for clinical practice. Korean Med Educ Rev. 2017;19(2):76–82. https://doi.org/10.17496/kmer.

68. Liu J, Zheng J, Liu K, Liu X, Wu Y, Wang J, You L. Workplace violence against nurses, job satisfaction, burnout, and patient safety in Chinese hospitals. Nurs Outlook. 2019;67:558–66. https://doi.org/10.1016/j.outlook.2019.04.006.

69. Zhang L, Wang A, Xie X, Zhou Y, Li J, Yang L, Zhang J. Workplace violence against nurses: a cross-sectional study. Int J Nurs Stud. 2017;72:8–14. https://doi.org/10.1016/j.ijnurstu.2017.04.002.

70. Kafle S, Paudel S, Thapaliya A, Acharya R. Workplace violence against nurses: a narrative review. J Clin Transl Res. 2022;8(5):421–4. PMID: 36212701.

71. Lin D, Bi J, Zhang X, Zhu F, Wang Y. Successful emotion regulation via cognitive reappraisal in authentic pride: Behavioral and event-related potential evidence. Front Hum Neurosci. 2022;13:16983674. https://doi.org/10.3389/fnhum.2022.983674.

72. Huang YM, Ma JS, Zhang HN. Freshman neuroticism and depression: the chain mediating role of expression inhibition and stress perception. Chin J Clin Psych. 2021;29:177–81. https://doi.org/10.16128/j.cnki.10053611.2021.01.036.

73. Balderas J, Bistricky SL, Schield S, Short MB. Spontaneous and instructed emotion regulation in dysphoria: effects on emotion experience and use of other emotion regulation strategies. Curr Psychol. 2021;40:1–14. https://doi.org/10.1007/S1214402101924Z.

74. Chen G, Zhang G, Yang Y, Zhang J, Hu Y. Relationships Between Negative Life Events and Depressive Symptoms for Chinese College Students: The Mediating Role of Rumination and Moderating Role of Perceived Social Support and Psychological Capital Psychology. Res Behav Manage. 2023;16:271–82. https://doi.org/10.2147/PRBM.S395551.

75. Hong S, Hanafi Z. Understanding time perspective's influence on academic burnout and achievement in Chinese undergraduates. Sci Rep. 2024;14(1):20430. https://doi.org/10.1038/s41598-024-71696-6.

76. Kennedy JC, Dunlop BW, Craighead LW, Nemeroff CB, Mayberg HS, Craighead WE. Assessing in-session rumination and its effects on CBT for depression. Behav Res Ther. 2022;159:104209. https://doi.org/10.1016/j.brat.2022.104209.

77. Zhou H, Liu H, Ma X, Deng Y. The psychometric properties of positive and negative beliefs about the rumination scale in Chinese undergraduates. BMC Psychol. 2023;11(1):107. https://doi.org/10.1186/s40359-023-01111-8.

78. Baojuan Ye D, Wu P, Wang H, Im M, Liu X, Wang Q, Yang. COVID–19 Stressors and Poor Sleep Quality: The Mediating Role of Rumination and the Moderating Role of Emotion Regulation Strategies. Int J Behav Med. 2022;29:416–25. https://doi.org/10.1007/s12529-021-10026-w.

79. Gross JJ. Emotion regulation: Current status and future prospects. Psychol Inq. 2015;26:1–26. https://doi.org/10.1080/1047840X.2014.940781.

80. Wang Y, Yin B. A new understanding of the cognitive reappraisal technique: an extension based on the schema theory. Front Behav Neurosci. 2023;17:1174585. https://doi.org/10.3389/fnbeh.2023.1174585.

81. Watkins ER, Roberts H. Reflecting on rumination: Consequences, causes, mechanisms and treatment of rumination. Behav Res Ther. 2020;127:103573. https://doi.org/10.1016/j.brat.2020.103573.

82. Li W, Li Y, Cao D. The effectiveness of emotion cognitive reappraisal as measured by self-reported response and its link to EEG alpha asymmetry. Behav Brain Res. 2021;400:113042. https://doi.org/10.1016/j.bbr.2020.113042.

83. Pan D-N, Hoid D, Wang X-B, Jia Z, Li X. When expanding training from working memory to emotional working memory: Not only improving explicit emotion regulation but also implicit negative control for anxious individuals. Psychol Med. 2022;52(4):675–84. https://doi.org/10.1017/S0033291720002275.

84. Long F, Zhou W, Zhang T, Zhang Z, Zhou R. Effects of Working Memory Training on Different Goals of Cognitive Reappraisal. Emotion. 2024;24(1):150–63. https://doi.org/10.1037/emo0001253.

Publisher's note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.