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Deciphering the psychological tapestry of FGIDs: unveiling the impact of negative affect, rumination, and expression suppression

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Abstract

Background Functional Gastrointestinal Disorders (FGIDs) constitute a group of psychosomatic diseases characterized primarily by disruptions in the functioning of the digestive system, profoundly impacting the lives of affected individuals.

Objective This study aims to investigate the influence of negative affect (NA) on the gastrointestinal symptoms of FGID patients, as well as the mediating role of rumination and the regulatory effects of expression suppression (ES) as an emotional regulation strategy.

Methods A survey was conducted on 1000 patients (403M, 597F) with gastrointestinal disorders at a tertiary hospital using the negative affect subscale from the DS-14 (Type D Personality Scale), the Gastrointestinal Symptom Rating Scale (GSRS), the Rumination Response Scale (RRS), and the expression suppression subscale from the Gross-John Emotion Regulation Strategy.

Results Negative affect positively predicts FGIDs, with rumination mediating the relationship between NA and FGIDs. The emotional regulation strategy of expression suppression moderates the positive relationship between NA and rumination and the mediating effect of rumination.

Conclusion NA exacerbates symptoms of FGIDs in individuals, and rumination further amplifies this effect, with the mediating influence evident across both high and low ES emotion regulation strategy groups.

Keywords Functional Gastrointestinal Disorders, Negative Affect, Rumination, Expression Suppression, Type D Personality

Introduction

Functional Gastrointestinal Disorders (FGIDs) constitute a group of diseases primarily characterized by disruptions in the functioning of the digestive system. Their hallmark is the presence of chronic or recurrent symptoms, including abdominal pain, abdominal distension, and abnormal bowel movements, persisting even after excluding other identifiable organic causes [1, 2]. While the clinical symptoms of FGIDs predominantly manifest in the digestive system, recent research increasingly underscores the impact of the mind-body relationship on the onset and development of FGIDs [3]. As a

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prototypical example of psychosomatic diseases, FGIDs exert influences on patients' lives that extend beyond the physiological realm, affecting various aspects of social, occupational, and family life [1, 3, 4]. Prolonged suffering often leads patients to experience a diminished quality of life [5–7].

One of the central mechanisms implicated in the development and persistence of FGIDs is the gut-brain axis. The gut-brain axis refers to the bidirectional communication network that links the central nervous system (CNS) and the enteric nervous system (ENS), integrating signals from the brain and gut to regulate gastrointestinal functioning [8]. This axis mediates the physiological responses to stress and is critical in how psychological factors can influence gastrointestinal symptoms [9]. Dysregulation of the gut-brain axis has been shown to contribute to the pathophysiology of FGIDs by amplifying visceral hypersensitivity, altering gut motility, and impacting the immune system [10]. However, while the gut-brain axis provides a physiological explanation for FGID symptoms, it is the psychological factors, particularly negative affect (NA), that we propose play a central role in modulating this axis, thereby exacerbating or alleviating symptoms.

Given the complex interplay of physiological, psychological, and environmental factors—such as life stress, coping mechanisms, and personality traits—an in-depth study of FGIDs, focusing on psychosocial contributors, becomes both urgent and crucial [11, 12]. As research deepens, increasing attention is being directed toward the psychological characteristics of individuals, with the D-type personality becoming a focal point of investigation [13–16]. The D-type personality, as a negative personality type, encompasses two main dimensions: NA and social inhibition (SI) [17]. This personality trait not only manifests in individuals' behaviors as negative thought patterns and social restraint but may also significantly influence the physiological activities of the brain-gut axis [14, 18, 19], becoming a potential mechanism leading to or exacerbating FGIDs. In this study, we focus on exploring the specific impact of the NA dimension within the D-type personality. We hypothesize that NA may interfere with individuals' coping mechanisms in the face of stress and the physiological mechanisms of the brain-gut axis. This impact can be explained as a more negative cognitive approach, leading individuals to respond poorly to stressors, potentially exacerbating the psychological burden of stress and forming a long-term negative cognitive bias. This speculation is largely supported by the Perseverative Cognition theory, which posits that persistent cognitive responses are a key factor contributing to compromised physiological health [20].

The Perseverative Cognition theory emphasizes a persistent, repetitive negative thinking pattern [17], represented by rumination. Rumination involves the repetitive, persistent, and indulgent contemplation of distressing situations and negative emotions [21, 22]. This ongoing cognitive process is crucial to mediating negative events, stressors, and sustained stress [21, 23, 24]. Therefore, our study explores the mediating role of rumination between NA and FGIDs.

Research indicates that individuals with effective emotion regulation are more likely to reduce rumination, diminishing the negative impact of rumination behaviour [25, 26]. Emotion regulation refers to the process of flexibly adjusting emotions and generating new emotions according to environmental demands [27], playing a crucial role in the adaptive functioning of individuals. Previous studies have operationalized emotion regulation ability by focusing on specific emotion regulation strategies employed by individuals, with a primary emphasis on Cognitive Reappraisal (CR) and Expression Suppression (ES) [17, 26].

In contrast to studies focusing on adaptive coping mechanisms [26, 28, 29], we adopt a non-adaptive coping perspective, specifically concentrating on ES. Individuals using the ES strategy inhibit their emotional expression [30, 31], aligning well with the cognitive style shaped by our environment, emphasizing the notion of "tolerate temporary calm the broader picture." [32]. Previous research has confirmed that ES is associated with fewer positive emotional experiences and expressions, more negative emotional experiences, poorer interpersonal functioning, and lower levels of happiness in adults [26]. Based on this, we hypothesize that ES, as a negative emotion regulation strategy, may exacerbate individual rumination. Therefore, it is crucial to delve into how ES intensifies individual rumination, consequently reinforcing the adverse effects of NA, ultimately exacerbating symptoms of FGIDs.

NA and FGIDs

This study posits that NA is a key factor in individuals developing FGIDs. NA refers to a negative emotional state experienced by individuals, including anxiety, depression, and so forth [33]. This negative emotion may impact the physiological system through various pathways, particularly regulating gastrointestinal functions [14, 19]. The mechanisms through which NA leads individuals to develop FGIDs are outlined below. Firstly, NA skews individuals' cognition toward the negative, making it difficult for them to cope with stress in their daily lives and work, thereby contributing to the onset of the disease [14, 34]. According to the Perseverative Cognition theory, this sustained negative emotion may lead individuals to respond negatively to environmental stressors, increase life burdens, and consequently affect the normal

functioning of the gastrointestinal tract [35]. Research suggests that in a negative emotional state, individuals may be inclined to adopt unhealthy lifestyle habits, such as changes in dietary habits and lack of exercise [36, 37]. These negative coping mechanisms and thought patterns may influence the normal functioning of the gastrointestinal tract through pathways like the neuroendocrine system and the immune system [38]. For instance, prolonged negative behaviour may cause chronic physiological stress, adversely affecting the motility and secretion of the gastrointestinal tract [39]. Additionally, persistent negative thinking may negatively regulate the neuroendocrine-immune system through the release of stress hormones, thereby affecting the normal functioning of the digestive system [38]. Consequently, these changes in lifestyle and thought patterns may be potential factors contributing to the further exacerbation of FGIDs symptoms. Based on the above analysis, we propose the following hypothesis:

> H1: NA is predictive of FGID presentation and severity. In other words, individuals are more likely to experience symptoms of FGIDs in an NA state.

Mediating role of rumination

To gain a deeper understanding of why individuals are more susceptible to developing FGIDs under the influence of NA, we introduce the psychological process of rumination and examine its mediating role between NA and FGIDs. Rumination is a psychological process referring to the repetitive contemplation and recollection of negative emotions, experiences, or problems, typically accompanied by anxiety, depression, or emotional distress [20]. In contrast to healthy psychological thinking and coping mechanisms, rumination may exacerbate NA and impede problem resolution [24]. Research indicates that rumination not only leads to sustained stress responses and negative emotional experiences in individuals but also further damages their physical health through pathways such as cardiovascular diseases and digestive system problems [37]. Unlike acute stressors, chronic rumination is considered an intermediary mechanism or ultimate transmission channel in the intricate interaction between negative emotions and the occurrence of physiological diseases [20]. Against the backdrop of the relationship between NA and FGIDs, we hypothesize that rumination may play a mediating role between NA and FGIDs. Specifically, individuals are more prone to enter a state of rumination under the influence of NA, and this state of rumination may further affect the manifestation of symptoms in FGIDs through psychophysiological mechanisms. Therefore, we propose the following hypothesis:

> H2: Rumination mediates the relationship between NA and FGIDs. In other words, negative emotions trigger a state of rumination, thereby exacerbating the manifestation of FGIDs symptoms.

Regulatory role of ES

Given that the presence of NA makes individuals more prone to rumination, we further explore whether this mediating effect may be exacerbated in different contexts. Based on Chinese individuals' cognitive style and tendencies, we hypothesize that emotion regulation strategies, especially ES, play a regulatory role between NA and rumination. Specifically, we speculate that ES may enhance the mediating effect of NA on rumination, thereby further intensifying the impact of NA on FGIDs. The Perseverative Cognition theory suggests that individuals are more likely to be trapped in rumination, forming a sustained negative thinking pattern under the influence of NA [20]. Although emotional regulation capabilities are generally associated with reduced rumination, in the context of high levels of ES, this strategy may lead to greater emotional suppression and persistence of rumination, thereby exacerbating symptoms related to FGIDs [40]. Related experimental studies have further found significant abnormalities in the emotion regulation brain circuits of individuals with high rumination compared to those with low rumination [41].

In summary, we propose the hypothesis:

> H3: ES contributes to the association between NA and rumination, and this relationship is significant in both high and low levels of ES among patients. In other words, ES strengthens the influence of NA on rumination.

While H2 suggests that NA affects individuals' FGIDs through rumination, H3 emphasizes the role of ES in regulating the relationship between NA and rumination. Integrating H2 and H3, this study proposes a moderated mediation model. The overall theoretical framework is presented in Fig. 1.

> H4: Individual ES positively regulates the indirect effect of NA on FGIDs through rumination. The indirect effects of emotional suppression will manifest more strongly in individuals with higher levels of ES.

Research methods

Data collection process and participants

Questionnaire survey data for this study were collected between January and August 2023 at a tertiary hospital in Guizhou Province. A convenience sampling method was employed to recruit patients diagnosed with FGIDs. The diagnosis of FGIDs in China, similar to international

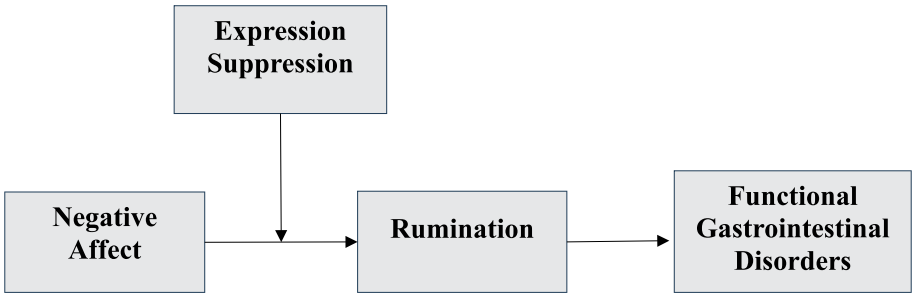

Fig. 1 Theoretical framework illustrating the mediating effect of rumination in the relationship between NA and FGIDs, moderated by ES

standards, is primarily based on the Rome IV criteria, which were used to identify specific FGIDs such as irritable bowel syndrome (IBS), functional dyspepsia (FD), functional constipation (FC), among others. Patients were approached during routine outpatient visits, and 1,113 eligible patients were fully informed about the study before providing written informed consent. To maintain the specificity of the sample, we excluded 98 patients with concurrent organic lesions, including peptic ulcers, inflammatory bowel disease, and gastrointestinal cancers, to ensure the sample consisted solely of patients with functional disorders. Additionally, we excluded patients currently undergoing treatment with medications known to affect gastrointestinal motility or sensitivity, such as opioids or certain psychotropic drugs. Patients using nutritional supplements were also screened to exclude those whose supplements could potentially alter gastrointestinal function.

After discarding 15 questionnaires with inadequate responses, we collected 1,000 valid questionnaires from individuals with functional gastrointestinal diseases, resulting in an effective response rate of 89.84%. The gender distribution showed 403 males (40.3%) and 597 females (59.7%). Participants ranged from 16 to 84 years, with a mean age of 44.5 years (*SD* = *16.94*). The distribution of FGIDs in the sample included 44% IBS, 32% FD, 15% FC, and 9% other FGIDs, with a mean time since diagnosis of 3.2 years *(SD* = *2.5)*. The severity of symptoms was assessed using the Gastrointestinal Symptom Rating Scale (GSRS), with 17% of patients reporting mild symptoms, 68% moderate, and 15% severe.

Measurement tools

Negative Affect (NA) was assessed using the Type D Personality Scale, DS-14 questionnaire developed by Denollet [42]. The scale consists of 14 items, with 7 items measuring NA, such as "I often make a big deal out of trivial matters," addressing irritability, worry, and anger. A 5-point scoring system was employed, ranging from 0 (not applicable) to 4 (highly applicable). Both NA and SI subscale scores range from 0 to 28. In this study, only the Negative Affect subscale was utilized, and its Cronbach's α coefficient in the current assessment was found to be 0.89.

Gastrointestinal symptoms(GI) were assessed in FGIDs patients using the Gastrointestinal Symptom Rating Scale (GSRS) developed by Svedlund [43] from Sweden. The GSRS is a specific scale consisting of 15 items designed to evaluate the gastrointestinal symptoms of patients over the past week. It covers five digestive symptoms: reflux, abdominal pain, indigestion, diarrhea, and constipation. A 4-point scoring system was employed, ranging from "asymptomatic" to "very severe," with higher scores indicating more severe symptoms. The Cronbach's α coefficient for this scale in the current assessment was 0.89.

Rumination was assessed using the Ruminative Responses Scale (RRS) developed by Professor Susan Nolen-Hoeksema from Yale University [22]. The scale consists of 22 items and is divided into three factors: symptom rumination, brooding, and reflective pondering. Participants rated each item on a scale of 1–4 (1 = never; 2 = sometimes; 3 = often; 4 = always), with higher total scores indicating a more severe tendency toward rumination. The Cronbach's α coefficient for the questionnaire administered in this study was 0.91.

Expression Suppression(ES) was measured using the Emotion Regulation Questionnaire (ERQ), developed by Gross [17] and colleagues. This tool primarily assesses individuals' tendencies in emotion regulation strategies. The questionnaire items 2, 4, 6, and 9 pertain to the ES dimension. Each item is rated on a 7-point scale (1 = not at all; 2 = a little; 3 = somewhat; 4 = uncertain; 5 = somewhat; 6 = a lot; 7 = very much). Higher scores on each dimension indicate a higher frequency of using the respective emotion regulation strategy. This study used only the Expression Suppression subscale, with a Cronbach's α coefficient of 0.87.

Data processing

Descriptive statistical analysis and correlation analysis were conducted using SPSS 22.0. Mplus 8 and the SPSS macro PROCESS 4.0 were employed to examine moderated mediation effects.

Results

Common method biases

The Harman single-factor test was employed to examine potential common method bias, which refers to the distortion of results due to using a single data source or measurement method. In our exploratory factor analysis, 12 eigenvalues exceeded 1, with the first factor explaining 23.63% of the variance, well below the 40% threshold that would indicate significant common method bias. Therefore, our analysis does not suffer from significant common method bias.

Correlation analysis of variables

Pearson correlation analysis examined the relationships between the variables (see Table 1). This method was chosen due to its suitability for assessing linear relationships between continuous variables. The revealed significant positive correlations between rumination and NA, ES, and GI. NA showed a significant positive correlation with ES and GI. However, there was no significant correlation between ES and GI. Additionally, age exhibited significant negative correlations with rumination, NA, ES, and GI, while education showed a significant positive correlation with rumination and a significant negative correlation with ES. Demographic variables were treated as control variables in subsequent analyses.

Hypothesis testing

This study used a hierarchical regression analysis to test hypotheses (Table 2). In Model 6, NA is a significant predictor of Gastrointestinal Symptoms (GI) ($\beta = 0.299$, $p < 0.001$), providing support for *H1*.

Moving to Model 2, NA positively influences Rumination ($\beta = 0.635$, $p < 0.001$). Model 7 illustrates that Rumination significantly and positively impacts GI symptoms ($\beta = 0.248$, $p < 0.001$), and the positive effect of NA on GI is also significant ($\beta = 0.141$, $p < 0.001$). Consequently, Rumination partially mediates these associations. Moreover, bootstrap testing confirms a distinct mediating effect, with a mediation value of $\beta = 0.158$, 95% CI = [0.099, 0.215], excluding 0 (see Table 3). The indirect effect surpassed the direct effect, suggesting that the mediating variable significantly explains the overall effect. Most independent variables influence the dependent variable through this mediating mechanism. *H2* receives support.

In Model 4, it is evident that the interaction term between Expression Suppression (ES) and NA significantly and positively influences Rumination ($\beta = 0.093$, $p < 0.001$). A simple slope analysis, depicted in Fig. 2, demonstrates that for patients with higher ES levels, the positive impact of NA on Rumination is noteworthy ($\beta = 0.693$, 95% CI = [0.632, 0.7], ns). Conversely, for patients with lower ES levels, the positive impact of NA on Rumination remains significant ($\beta = 0.507$, 95% CI = [0.439, 0.575], $p = 0.098$). The results from this modelling supported the third hypothesis (*H3*), which postulated that ES would accentuate the influence of NA and rumination.

In the low-ES emotion regulation group, the indirect effect between NA and FGIDs symptoms through rumination is robust ($\beta = 0.126$, 95% CI = [0.081, 0.175], $p < 0.001$). Similarly, in the high ES emotion regulation group, the indirect effect is also statistically significant ($\beta = 0.172$, 95% CI = [0.107, 0.238], $p < 0.001$). Although there is no statistically significant difference in the indirect effects between the two levels ($p > 0.05$), individuals with high ES levels exhibit a higher β value for the indirect effect compared to the low ES group. In conclusion, *H4* is supported.

Table 1 Descriptive statistics and correlation coefficients among variables

Variable	*M*	*SD*	1	2	3	4	5	6	7	8
1 Gender	1.6	0.491	1							
2 Age	44.5	16.942	0.036	1						
3 Education	3.14	1.089	-0.006	-0.419**	1					
4 Occupation	4.00	2.088	0.073*	0.093**	-0.467**	1				
5 Rumination	32.94	10..39	0.046	-0.153**	0.091**	-0.033	1			
6 Negative Affect	8.40	5.96	0.053	-0.071*	-0.009	0.012	0.641**	1		
7 Expressive Suppression	14.23	6.55	0.007	-0.063*	0.031	-0.007	0.260**	0.262**	1	
8 Gastrointestinal symptoms	23.73	6.48	-0.013	-0.01	-0.006	-0.041	0.330**	0.297**	0.120**	1

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 2 Results of hierarchical regression analysis of the mediating effect of rumination

	Rumination				Gastrointestinal symptoms		
	M1	M2	M3	M4	M5	M6	M7
Control variate							
Age	-0.143***	-0.083**	-0.079**	-0.077**	-0.022	0.005	-0.051**
Education	0.026	0.057	0.056*	0.062*	-0.042	-0.023	0.548-*
Occupation	0.012	-0.008	-0.008	-0.008	-0.058	-0.053	-0.051
Gender	0.052	0.015	0.016	0.019	-0.008	-0.024	-0.028
Independent variable							
Negative Affect		0.635***	0.611***	0.6***		0.299***	0.141***
Moderator variable							
Expressive Suppression			0.093***	0.093***			
Interaction term							
Negative Affect * Expressive Suppression				0.093** *			
Mediating variable							
Rumination							0.248***
Adjust the R^2	0.023	0.425	0.434	0.444	0.001	0.087	0.121
ΔR^2	0.027	0.653	0.659	0.666	0.003	0.091	0.127
F	6.926***	147.402***	126.824***	113.17***	0.744	19.944***	23.971***

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$

Table 3 Total, direct, indirect and moderated mediation effects (Bootstrap = 5000)

	β	*SE*	95% LLCI	95% ULCI	Relative Effect
Total effect	. 299	. 030	. 239	. 358	
Direct effect	. 121	. 039	. 065	. 217	40 . 47%
Indirect effect	. 178	. 029	. 099	0.215	59 . 53%

Discussion

Theoretical significance

In our study, we observed a relatively higher proportion of male participants (40.3%) compared to the lower male prevalence reported in other FGID studies [44, 45]. However, our analysis did not reveal significant correlations between gender and the key psychological and emotional

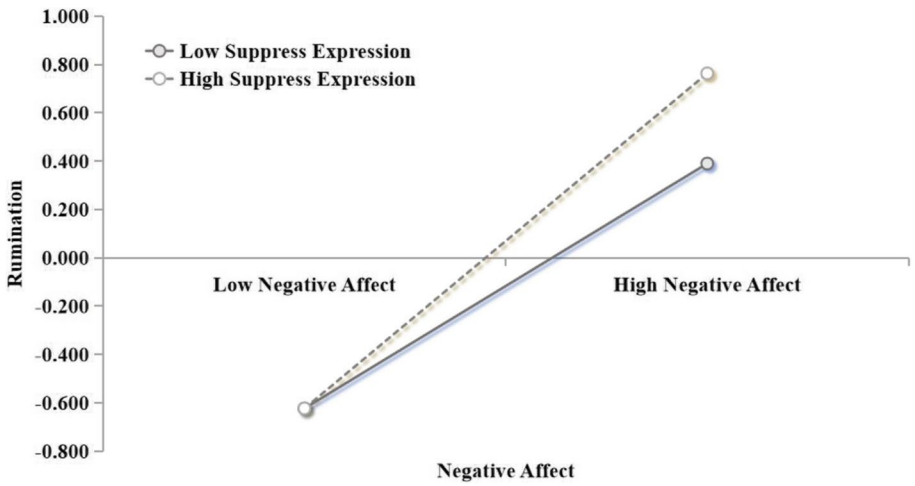

Fig. 2 The moderating effect of ES on the relationship between NA and rumination. Higher levels of ES (solid line) show a stronger positive relationship between NA and rumination (β = 0.693, 95% CI = [0.632, 0.7]), while lower levels of ES (dotted line) show a weaker but still significant relationship (β = 0.507, 95% CI = [0.439, 0.575])

variables, including NA, Rumination, ES, and Gastrointestinal symptoms. This gender distribution may be influenced by regional dietary habits in Guizhou Province, such as the frequent consumption of high-proof spirits like baijiu and spicy, high-fat foods [46, 47]. Additionally, cultural factors may also play a role in shaping psychological and emotional responses, which could explain the lack of significant gender differences observed in this population. For instance, in contrast to European and American populations, where women are more likely to experience depression, negative affect, and gastrointestinal symptoms, while men may exhibit psychosomatic effects in the form of cardiovascular disease [48]. Such patterns may not be as pronounced in Chinese populations due to different cultural norms and behaviors. In the Chinese context, traditional norms may encourage men to suppress emotional expression [49], potentially masking the emotional and psychological factors commonly observed in Western populations. While we did not observe significant gender differences in this study, we believe that this topic warrants further exploration. Future research could examine how cultural and regional factors influence gender-specific experiences of NA and GI symptoms, expanding on the findings of this study.

In this section, we highlight the theoretical significance of our findings. First, the study underscores the pivotal role of NA as a psychological determinant in predicting symptoms of FGIDs. While traditional research has predominantly focused on physiological mechanisms and lifestyle habits [50, 51], our study introduces a fresh psychological perspective, emphasizing NA as an innovative antecedent variable.

Second, anchored in Perseverative Cognition theory, our investigation introduces rumination as a mediating variable to unravel the intricate mechanism through which NA influences FGIDs symptoms. Our results illuminate rumination's mediating role between NA and FGIDs symptoms. Faced with life or work stressors, patients typically undergo self-adjustment processes. Yet, owing to patients' negative cognitive bias, this process leads to persistent, intrusive thinking about distressing situations and negative emotions. Consequently, it results in prolonged stress and negative emotional experiences [21]. This process may trigger gastrointestinal symptoms by impacting neuroendocrine-immune system secretion [24]. These findings resonate with prior research, affirming rumination's mediating role between stressors and disease.

Third, operating within the Perseverative Cognition framework, our study unveils a non-adaptive coping mechanism of NA with FGIDs symptoms: the positive regulatory effect of ES. The results illustrate that ES, as a negative emotion regulation strategy, intensifies individual levels of rumination, thereby amplifying the adverse effects of NA and ultimately exacerbating FGIDs symptoms. This observation not only corroborates the detrimental impact of ES as an emotion regulation strategy in negative events [29, 40] but also supports the established understanding of rumination and its link to negative affect [52], while deepening our comprehension of NA's role in individual adaptive coping.

Clinical implications

In this section, we outline the clinical implications of our findings. Firstly, healthcare professionals should prioritize patients' NA in clinical practice, incorporating it into symptom assessments and treatment plans. By comprehensively understanding patients' psychological well-being, the medical team can tailor interventions more precisely, thereby enhancing treatment effectiveness. Additionally, we recommend establishing a standardized procedure to ensure every patient receives appropriate psychological support. Secondly, within the framework of the Perseverative Cognition theory, we recognize that rumination mediates between NA and FGIDs symptoms. To address this, psychological interventions such as cognitive-behavioral therapy (CBT) [1], mindfulness-based stress reduction (MBSR) [21], and acceptance and commitment therapy (ACT) [21]can be employed to help patients manage and reduce rumination. These interventions focus on breaking the cycle of negative thought patterns, mitigating their impact on the disease's progression. Lastly, the study underscores ES as a negative emotion regulation strategy that may harm adaptive coping. To counteract this, clinical practice should include training in adaptive emotion regulation strategies, such as cognitive reappraisal [26, 27]and emotional acceptance [53]. These approaches can help patients reduce emotional suppression and develop healthier ways to cope with stressors, which may slow down symptom progression. A close collaborative relationship between the medical team and patients is essential in developing personalized emotional management plans that address these needs.

Limitations of study

This study has several limitations: 1. Sample Representativeness: Although we selected FGIDs patients as the study population, the diversity within this patient group may limit the generalizability of the research findings. Future studies could encompass a broader range of patient demographics to ensure the widespread applicability of the results. 2. Wide Age Range: The study included a wide age range of participants, and the varied

life experiences of these patients, influenced by significant historical and cultural changes in China over the past several decades, may affect their FGID symptoms and psychological processes. 3. Cross-Sectional Design Constraints: This study's cross-sectional design might restrict a comprehensive understanding of causal relationships. Future research should employ more longitudinal study designs to unveil the causal relationships between NA, rumination, and ES. 4. Diversity in Emotion Regulation Strategies: While this study focuses on ES as an emotion regulation strategy, patients might employ various strategies when dealing with negative emotions. Subsequent research should comprehensively consider the impact of different emotion regulation strategies, deepening our understanding of their roles in developing FGIDs. 5. Gender Considerations: This study did not specifically focus on gender differences, which is a limitation given the likelihood of differences in psychological processes between men and women. For example, research suggests that women are more prone to experience negative affect and somatize these effects physically [21]. Future studies should explore gender differences to better understand their impact on FGID symptoms.

Future directions

Building upon the findings of this study, there are several avenues for future research: 1. More Personalized Intervention Strategies: Customizing interventions to address the specific needs of distinct patient groups holds promise for enhanced efficacy. Personalized interventions have the potential to more effectively support patients in managing negative emotions and mitigating the risk of FGIDs. 2. Long-Term Effect Studies: To comprehensively evaluate the effectiveness of emotion regulation strategy, investigating interventions' sustained impact over the long term is essential. This approach contributes to a deeper understanding of the endurance of interventions and their prolonged influence on FGIDs symptoms. 3. Integration of Biomarkers: A more holistic comprehension of the influence of emotion regulation strategies on physiological mechanisms can be achieved by contemplating the integration of biological facets, such as neuroimaging or biomarker measurements.

Conclusion

NA exacerbates symptoms of FGIDs in individuals, and rumination further amplifies this direct effect. This mediating effect is present in high and low ES emotion regulation strategy groups. Individuals with high ES emotion regulation display elevated levels of rumination compared to those with low ES emotion regulation, intensifying the regulatory effect in the model.

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Authors' contributions
X.X.M. and Z.H.X. contributed equally to this work and are considered co-first authors.X.X.M. wrote the main manuscript. W.C. and S.Y.Z performed the statistical analysis. Z.H.X. conceived and designed the study. X.X.M .collection the data.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study has been reviewed and approved by the Ethics Committee of the Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine, with approval number EC2023008.
Our research has been communicated to the participants, and the study was conducted with their informed consent. At every research stage, we have rigorously adhered to the ethical guidelines and regulations prescribed by the institution. During the data analysis phase, stringent measures were implemented to protection privacy.

Consent for publication
All authors have provided consent for the publication of the research findings.

Competing interests
The authors declare no competing interests.

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