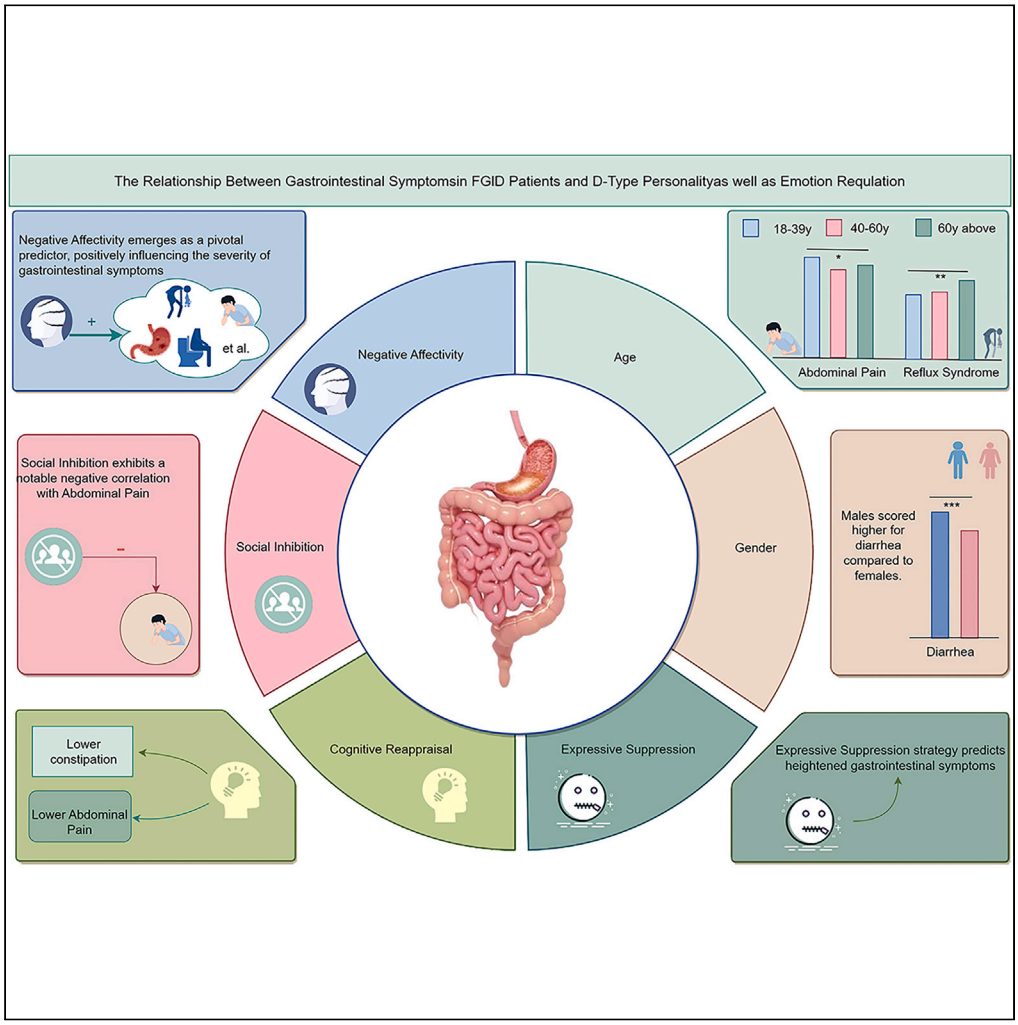
iScience

CellPress
OPEN ACCESS

Article

The relationship between gastrointestinal symptoms in FGID patients and D-type personality and emotion regulation strategies



Xin-Xin Ma, Zheng-Hua Xiao, Wei Chen, Shou-Ying Zhao

435204673@qq.com

Highlights

Gender and age impact FGID symptoms

Negative affectivity predicts symptom severity

Cognitive reappraisal mitigates symptom severity

D-type personality and emotion regulation influence FGID

Ma et al., iScience 27, 109867
June 21, 2024
https://doi.org/10.1016/j.isci.2024.109867

iScience

CellPress
OPEN ACCESS

Article

The relationship between gastrointestinal symptoms in FGID patients and D-type personality and emotion regulation strategies

Xin-Xin Ma,[1] Zheng-Hua Xiao,[2,4,*] Wei Chen,[1] and Shou-Ying Zhao[1,3]

SUMMARY

This study examines the relationship between gastrointestinal symptoms in patients with functional gastrointestinal disorders (FGIDs) and type D personality traits, as well as emotion regulation strategies. Analyzing a diverse group of FGID patients, we uncover significant effects of gender and age on gastrointestinal symptoms. Negative Affectivity emerges as a key predictor, positively associated with symptom severity, whereas Social Inhibition correlates negatively with Abdominal Pain. Additionally, our findings suggest that the expressive suppression strategy predicts heightened gastrointestinal symptoms, whereas cognitive reappraisal predicts lower levels of certain symptoms. These findings provide valuable insights for precise diagnosis and tailored treatments of FGIDs. Further research is warranted to explore underlying mechanisms and inform evidence-based interventions.

INTRODUCTION

Functional gastrointestinal disorders (FGIDs) represent a complex set of gastrointestinal diseases characterized by the absence of discernible organic abnormalities in routine medical examinations. Nevertheless, patients frequently report various gastrointestinal symptoms such as abdominal pain, diarrhea, constipation, reflux syndrome, and indigestion.[1] Importantly, these symptoms are not solely linked to physiological aspects but are closely intertwined with psychological and social factors, including anxiety, depression, social isolation, and diminished quality of life.[2] Furthermore, individual differences such as gender, age, and educational level significantly contribute to the generation and manifestation of these symptoms. For example, research indicates that the majority of FGIDs, such as irritable bowel syndrome (IBS), bloating, constipation, and chronic functional abdominal pain, have a higher prevalence rate in women compared to men.[3,4] Additionally, FGIDs impact individuals of all ages. While some FGIDs become more prevalent as individuals age, such as constipation, as suggested by Houghton et al. (2016), others, like IBS, may decline or show mixed findings.[5] Lower educational level has also been identified as one of the risk factors for FGID, as indicated by another study.[6] Moreover, research has found differences in the prevalence of FGIDs among patients with comorbid chronic diseases.[7,8] Due to the diverse nature of FGIDs and unclear physiological mechanisms, research into their etiology and treatment remains challenging in the medical field.

D-type personality encompasses emotional characteristics, primarily negative affectivity and social inhibition.[9] Negative affectivity involves anxiety, depression, and anger, whereas social inhibition includes introversion, loneliness, and emotional suppression. Individuals with D-type personalities are more susceptible to experiencing anxiety and negative emotions,[10] potentially impeding their ability to cope effectively with life stressors.[11] Recent studies have extensively explored the relationship between D-type personality and physical health, revealing a significant correlation with various health issues such as cardiovascular diseases,[12] gastrointestinal symptoms,[10,13] and muscle pain,[14] leading to its classification as a "distressed personality."[15,16] Previous research has indicated that individuals with D-type personality exhibit a notably higher severity of gastrointestinal symptoms compared to non-D-type individuals,[10] sparking interest in exploring the potential commonality between D-type personality and the onset of FGIDs. Numerous studies consistently confirm that negative emotions primarily mediate the impact of D-type personality on health.[17] Thus, the potential correlation between D-type personality and FGIDs underscores the significance of emotions and other psychological factors in health issues, hinting at the possibility of shared mechanisms and impact pathways across different diseases.

In this context, effective regulation of negative emotions becomes crucial. Emotion regulation, as a psychological resource, can significantly enhance the adaptation of FGID patients under stressful conditions. Emotion regulation involves influencing emotions' type, timing, experience, and expression.[18] This process, occurring during emotional responses, can weaken or intensify emotional reactions in amplitude or duration. Reducing the duration or intensity of negative emotions is especially crucial for maintaining individual physical and mental

[1]School of Psychology, Guizhou Normal University, Guiyang, Guizhou 550025, China
[2]The Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine, Guiyang, Guizhou 550003, China
[3]Kaili University, Kaili, Guizhou 556011, China
[4]Lead contact
*Correspondence: 435204673@qq.com
https://doi.org/10.1016/j.isci.2024.109867

health.[19] Emotion regulation strategies, categorized into two types by Gross,[18] include cognitive reappraisal and expressive suppression. Cognitive reappraisal, an antecedent-focused strategy, influences behavior and physiological reactions by altering cognition before the individual expresses an emotional response,[20] aiming to control the "entry" of emotions.[18] As a positive emotion regulation strategy, cognitive reappraisal can buffer individuals against the negative emotions resulting from the perceived stress of high-risk events.[21] In contrast, expressive suppression is a response-focused strategy involving individuals controlling the physiological reactions of emotions and reducing the external behaviors and facial expressions of emotional expression after the emotional response has been output. This strategy aims to conceal emotions as much as possible, controlling the "output" of emotions.[20] Studies have shown that expressive suppression is significantly positively correlated with individuals' anxiety, depression, loneliness, and more.[22] Therefore, cognitive reappraisal is a positive emotion regulation strategy involving reevaluating situations to alleviate negative emotions, contributing to emotion regulation and psychological health.[23] In contrast, expressive suppression is a negative strategy that requires individuals to suppress the external expression of emotions, potentially leading to internal emotional suppression and tension, adversely affecting psychological and physiological health.[24] Individuals with D-type personalities typically exhibit social inhibition, making them more likely to adopt negative expressive suppression strategies to cope with stress and negative emotions.[9,11]In Chinese culture, characterized by collectivism, individuals emphasize emotional restraint to control emotions by suppressing internal emotional experiences and behaviors, aiming to maintain social harmony and respect for others.[25] However, this emotional restraint may have adverse effects on the digestive system. Prolonged emotional suppression may lead to chronic changes in the gastrointestinal mucosa,[13] ultimately evolving into chronic gastritis and intestinal metaplasia, increasing the risk of cancer.

In summary, FGID patients may be influenced by three individual factors: (1) demographic variables such as gender, age, and education level; (2) personality traits; and (3) the use of individual emotion regulation strategies. Therefore, this study explores the impact of demographic variables, D-type personality, and emotion regulation strategies on Gastrointestinal Symptom Rating Scale (GSRS) symptoms in FGID patients, providing theoretical references and practical guidance for improving GSRS. To achieve this, we propose the following hypotheses regarding the influence of each factor on gastrointestinal symptom severity in FGID patients.

(1) Demographic variables hypothesis: we hypothesize that demographic variables such as gender, age, and educational level are significantly associated with GSRS scores. Specifically, we anticipate that females may experience more severe symptoms in all dimensions than males, older individuals may be more prone to high GSRS scores, and lower educational attainment may be negatively correlated with GSRS scores.
(2) D-type personality hypothesis: we anticipate that individuals exhibiting D-type personality traits will demonstrate higher GSRS scores compared to those without such traits, suggesting a link between negative affectivity and gastrointestinal symptom severity.
(3) Emotion regulation strategies hypothesis: we predict that the use of emotion regulation strategies, particularly cognitive reappraisal and expressive suppression, will be associated with GSRS scores in FGID patients. Specifically, cognitive reappraisal is expected to demonstrate a negative correlation, whereas expressive suppression is expected to show a positive correlation with symptom severity.

RESULTS

Analysis of differences in GSRS among FGID patients in demographic variables

Table 1 presents the results of the analyzing of GSRS differences among FGID patients based on demographic variables. In terms of gender differences, males exhibited a significantly higher score in Diarrhea compared to females. However, despite higher scores in females, the differences did not achieve statistical significance for other dimensions. Turning to the influence of comorbidities, there were no statistically significant score differences across all dimensions between patients with or without other chronic diseases. Notably, patients with combined chronic diseases scored higher than those without such comorbidities.

Examining age group differences, the 18–39 years age group showed a significantly higher score in Abdominal Pain compared to the 40–60 years and 60 years and above age groups. Conversely, the score for Reflux Syndrome in the 18–39 years age group was significantly lower than the other two age groups. In the 60 years and above age group, the score for Abdominal Pain was significantly higher than the 40–60 years age group but lower than the 18–39 years age group. Additionally, the score for Reflux Syndrome in the 60 years and above age group was significantly higher than in the other two age groups. Notably, the 40–60 years age group scored significantly lower than the 18–39 years and 60 years and above age groups in both Abdominal Pain and Reflux Syndrome. No statistically significant differences were found in scores for other dimensions.

To comprehensively explore the impact of age and gender on GSRS and its sub-dimensions and to minimize the loss of information caused by age grouping, we utilized age as a continuous variable and conducted regression analysis (see Table 2). This approach not only preserves data integrity but also allows for a more in-depth analysis of the relationship between age, gender, and GSRS and its sub-dimensions.

Regression analysis results suggest that the relationship between age and various GSRS symptoms shows some degree of correlation, although this association is not universal. Specifically, there appears to be a correlation between age and indigestion and abdominal pain, whereas the correlation with diarrhea, constipation, and reflux symptoms is weaker. Additionally, there is little to no significant correlation between age and GSRS symptoms in terms of the overall GSRS score.

On the other hand, the relationship between gender and different GSRS symptoms also exhibits some variation. For instance, there seems to be a positive correlation between gender and diarrhea, whereas the correlation with indigestion, constipation, reflux symptoms, and the GSRS total score is weaker. Furthermore, there appears to be a weak negative correlation between gender and abdominal pain.

Table 1. Differential analysis of GSRS scores and sub-dimensions among FGID patients in demographic variables

Variable	Indigestion	Diarrhea	Constipation	Abdominal pain	Reflux syndrome	GSRS
Gender						
Male (n = 502)	7.18 ± 2.47	4.55 ± 1.96	4.36 ± 1.77	4.55 ± 1.57	3.16 ± 1.49	1.58 ± 0.45
Female (n = 409)	7.23 ± 2.45	4.16 ± 1.62	4.46 ± 1.85	4.63 ± 1.63	3.20 ± 1.55	1.57 ± 0.41
T	−. 270	3.375***	−. 843	−. 811	−. 367	. 293
FDR p	0.735	0.000	0.51	0.554	0.823	0.823
Combined with other chronic diseases						
Yes (n = 182)	7.61 ± 2.45	4.37 ± 1.86	4.93 ± 1.90	4.67 ± 1.62	3.35 ± 1.56	1.66 ± 0.40
No (n = 729)	7.18 ± 2.43	4.30 ± 1.78	4.40 ± 1.82	4.59 ± 1.60	3.18 ± 1.53	1.57 ± 0.43
T	1.164	. 239	1.953	. 336	. 703	1.306
FDR p	0.974	0.982	0.974	0.974	0.974	0.982
Age						
18–39 (n = 417)	7.14 ± 2.48	4.45 ± 1.83	4.41 ± 1.79	4.77 ± 1.69	3.02 ± 1.45	1.58 ± 0.43
40–60 (n = 381)	7.21 ± 2.45	4.24 ± 1.68	4.36 ± 1.72	4.44 ± 1.55	3.25 ± 1.53	1.56 ± 0.42
60 above (n = 113)	7.38 ± 2.44	4.16 ± 1.82	4.55 ± 2.08	4.53 ± 1.53	3.42 ± 1.64	1.60 ± 0.44
F	0.599	2.343	0.675	4.612*	4.885**	0.493
FDR p	0.678	0.39	0.678	0.010	0.008	0.611
Education						
Primary school (n = 52)	7.44 ± 2.57	4.41 ± 2.02	4.54 ± 2.09	4.84 ± 1.83	3.13 ± 1.51	1.62 ± 0.47
Junior middle school (n = 163)	7.24 ± 2.45	4.24 ± 1.78	4.55 ± 1.91	4.70 ± 1.58	3.27 ± 1.59	1.60 ± 0.44
High school or secondary vocational school (n = 249)	6.89 ± 2.35	4.08 ± 1.58	4.23 ± 1.67	4.43 ± 1.52	3.15 ± 1.50	1.51 ± 0.39
University graduate (n = 401)	7.38 ± 2.52	4.45 ± 1.82	4.46 ± 1.83	4.62 ± 1.63	3.17 ± 1.49	1.60 ± 0.43
Postgraduate (n = 46)	6.91 ± 2.27	4.63 ± 1.75	4.33 ± 1.56	4.37 ± 1.54	3.20 ± 1.73	1.56 ± 0.40
F	1.905	2.199	1.081	1.599	222	1.956
FDR p	0.172	0.172	0.402	0.234	0.902	0.172

***p < 0. 001, **p < 0. 01, *p < 0. 05; ±: standard deviations (SD).

Analysis of the relationship between GSRS symptoms, type D personality, and emotional regulation strategies in FGID patients

Correlation analysis was employed to explore the connections among GSRS symptoms, type D personality, and emotional regulation strategies in FGID patients. The findings reveal a significant positive correlation between the overall GSRS level and symptoms such as Indigestion, Diarrhea, Constipation, Abdominal Pain, and Reflux, as well as expressive suppression, negative affectivity, and social inhibition. Furthermore, Cognitive Reappraisal significantly correlates with all variables and dimensions except for Abdominal Pain. Notably, no significant correlations were observed for the other variables and dimensions (refer to Table 3).

Utilizing the two dimensions of type D personality, Negative Affectivity and Social Inhibition, as independent variables, distinct multiple regression analyses were performed for GSRS and its five sub-dimensions. The purpose was to investigate the predictive roles of Negative Affectivity and Social Inhibition on GSRS. As illustrated in Table 4, Negative Affectivity demonstrates a significant positive predictive effect on Indigestion, Diarrhea, Constipation, Abdominal Pain, Reflux, and overall GSRS. This implies that higher scores of Negative Affectivity are linked to gradual increases in Indigestion, Diarrhea, Constipation, Abdominal Pain, Reflux, and GSRS levels among FGID patients. Conversely, Social Inhibition exhibits a significant negative predictive effect on Abdominal Pain, suggesting that an increase in Social Inhibition levels is associated with a decrease in Abdominal Pain among FGID patients. However, no such impact was observed on GSRS and the other four dimensions. The combined explanatory power of Negative Affectivity and Social Inhibition on the overall GSRS level is 18.5%. Regarding Indigestion, Diarrhea, Constipation, Abdominal Pain, and Reflux, the explanatory rates are 14.5%, 12.5%, 11.9%, 15.2%, and 12.4%, respectively.

Using Expressive Suppression and Cognitive Reappraisal as independent variables, separate multiple regression analyses were conducted for GSRS and its five sub-dimensions. This aimed to examine the predictive roles of Expressive Suppression and Cognitive Reappraisal on GSRS. As indicated in Table 5, Expressive Suppression demonstrates a significant positive predictive effect on Indigestion, Diarrhea, Constipation, Abdominal Pain, and overall GSRS. This implies that with an increased use of Expressive Suppression, levels of Indigestion, Diarrhea,

Table 2. Regression analysis of age and gender on GSRS and its sub-dimensions

Dependent variable	Independent variable	R^2	Standardized coefficients	t	FDR *p*
Age	Indigestion	0.004	−0.074	−2.321	0.08
	Diarrhea	0002	−0.058	−1.811	0.168
	Constipation	0. 119	−0.001	0.012	0.923
	Abdominal pain	0.001	0.049	1.012*	0.032
	Reflux	0.003	−0.097	−2.983**	0.007
	GSRS	−0.001	−0.003	−0.086	0.932
Gender	Indigestion	0.000	0.026	0.811	0.627
	Diarrhea	0.000	0.023	0.727***	<0.001
	Constipation	0.000	0.027	0.843	0.627
	Abdominal pain	0.007	−0.090	−2.842*	0.03
	Reflux	−0.001	0.005	0.158	0.932
	GSRS	−0.001	−0.009	−0.293	0.9228

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

Constipation, Abdominal Pain, and GSRS gradually rise among FGID patients, with Reflux unaffected by Expressive Suppression. On the other hand, Cognitive Reappraisal shows a significant negative predictive effect on Constipation, Abdominal Pain, and overall GSRS. This suggests that with an increased use of Cognitive Reappraisal, levels of Constipation, Abdominal Pain, and GSRS gradually decrease among FGID patients. The combined explanatory power of Expressive Suppression and Cognitive Reappraisal on the overall GSRS level is 18.1%. For Indigestion, Diarrhea, Constipation, Abdominal Pain, and Reflux, the explanatory rates are 11.7%, 11.0%, 12.6%, 23.2%, and 1.2%, respectively.

DISCUSSION

Current status of GSRS in FGIDs patients

The analysis of differences in GSRS among FGID patients based on demographic variables revealed some statistically significant findings. For instance, there were significant differences in GSRS scores based on gender and age groups. However, the patterns observed do not fully align with the hypothesis that demographic variables such as gender, age, and education level will significantly correlate with GSRS scores across all dimensions. Although there were significant differences in specific dimensions (e.g., Diarrhea and Abdominal Pain) among different demographic groups, other dimensions did not show significant correlations. Regression analysis results suggest that the impact of age and gender on GSRS is consistent with the trends observed in the correlation analysis. Therefore, the results partially support the demographic variables hypothesis.

Specifically, male FGID patients show significantly higher scores in the Diarrhea dimension compared to females. Interestingly, our findings challenge our initial hypothesis and deviate from previous research.[3,4] This disparity may be linked to biological and physiological factors, such as intestinal motility and hormone levels.[26] Additionally, dietary[27] and lifestyle factors[28] could play a role. Research indicates that, compared to females, males are more likely to consume diets that negatively affect normal intestinal physiology, including a higher intake of high-fat and alcoholic beverages.[27] Studies reveal that males subjected to stricter discipline during childhood are more prone to diarrhea in adulthood.[29] Traditional Chinese education norms, allocating more responsibilities to males in family and school settings,[30] may explain their increased susceptibility. Previous studies have suggested that female FGID patients may exhibit higher levels of constipation symptoms compared to males.[3,4] However, surprisingly, our research results showed no significant gender differences in the Constipation dimension. This finding is intriguing, indicating that our understanding of the role of gender in FGIDs is still incomplete. While there may be physiological differences between males and females, these differences may sometimes offset each other, resulting in no apparent differences between the sexes in specific situations. For example, although the intestinal structures of males and females may vary, other factors such as dietary habits may equalize constipation between genders, with studies indicating that females are more likely to have adequate dietary fiber intake.[31] In other dimensions, no statistically significant gender differences indicate similar symptom manifestation between males and females in other FGIDs aspects. This suggests a dimension-specific impact of gender on FGIDs, highlighting the need for future research exploring gender influence and considering biological and social factors for a comprehensive understanding.

In the age dimension, the 18–39 years age group demonstrates higher scores in the Abdominal Pain dimension, indicating a higher susceptibility to experiencing or perceiving abdominal pain symptoms among younger individuals, which is consistent with previous research findings.[32,33] Factors such as life challenges, increased stress, work pressure, and changes in diet and lifestyle commonly experienced by individuals in this age range may contribute to the perception and expression of abdominal pain.[33] Conversely, the 60 years and above age group exhibits higher scores in the Reflux Syndrome dimension, suggesting an increased likelihood or sensitivity to reflux symptoms in older individuals, which is in line with prior studies.[34] Age-related physiological changes, such as relaxation of the esophageal sphincter and

Table 3. Correlation matrix between GSRS symptoms, type D personality, and emotional regulation strategies

	M	SD	GSRS	Indigestion	Diarrhea	Constipation	Abdominal pain	Reflux	Cognitive reappraisal	Expressive suppression	Negative affectivity	Social inhibition
GSRS	1.58	0.43	1									
Indigestion	7.21	2.46	0.838**	1								
Diarrhea	4.31	1.77	0.575**	0.354**	1							
Constipation	4.42	1.82	0.613**	0.404**	0.278**	1						
Abdominal Pain	4.60	1.61	0.619**	0.409**	0.271**	0.240**	1					
Reflux	3.18	1.52	0.569**	0.420**	0.166**	0.196**	0.311**	1				
Cognitive Reappraisal	14.21	6.53	−0.023	0.006	0.002	−0.018	−0.063*	−0.05	1			
Expressive Suppression	25.40	9.64	0.123**	0.084**	0.100**	0.077*	0.095**	0.006	0.388**	1		
Negative Affectivity	15.38	5.92	0.277**	0.228**	0.179**	0.201**	0.195**	0.118**	0.028	0.245**	1	
Social Inhibition	16.62	4.56	0.205**	0.169**	0.128**	0.162**	0.146**	0.055	0.106**	0.251**	0.748**	1

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

Table 4. Regression analysis of GSRS and its sub-dimensions on type D personality

Dependent variable	Independent variable	R^2	Standardized coefficients	t	FDR *p*
Indigestion	Social Inhibition	0.145	−0.034	−0.564	0.565
	Negative Affectivity		0.237	36.874***	<0.001
Diarrhea	Social Inhibition	0.125	−0.071	−1.145	0.104
	Negative Affectivity		0.203	31.290***	<0.001
Constipation	Social Inhibition	0. 119	0.012	0.201	0.982
	Negative Affectivity		0.189	28.088**	0.005
Abdominal Pain	Social Inhibition	0. 152	−0. 079	−11.296***	0.0009
	Negative Affectivity		−0.281	39. 622***	<0.001
Reflux	Social Inhibition	0.124	−0.103	−1.672	0.104
	Negative Affectivity		−0.216	30.507***	<0.001
GSRS	Social Inhibition	0.185	−0.048	−1.064	0.110
	Negative Affectivity		0.428	47.233***	<0.001

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

increased gastric acid secretion, may contribute to the heightened reflux symptoms observed in this age group.[34,35] These findings support the hypothesis that older individuals may be more prone to experiencing higher GSRS scores, particularly in dimensions related to reflux symptoms.

Unlike the other studies,[7,8] our results on education level and comorbid chronic diseases show no significant score differences across all dimensions. This implies that education level and the presence of chronic diseases may not be critical factors influencing FGIDs symptoms. However, this result may be influenced by sample size or other unconsidered factors, necessitating larger-scale studies to validate these findings.

Relationship between type D personality and GSRS in FGIDs patients

The analysis of the relationship between GSRS symptoms, type D personality, and emotional regulation strategies revealed significant positive correlations between overall GSRS levels and type D personality traits, particularly Negative Affectivity. These findings support the hypothesis that individuals exhibiting D-type personality traits will demonstrate higher GSRS scores than those without such traits. Additionally, the multiple regression analyses showed a significant positive predictive effect of Negative Affectivity on various dimensions of GSRS, further supporting this hypothesis. Abundant research indicates a significant association between type D personality and various health issues, including cardiovascular diseases,[12] gastrointestinal symptoms,[10,13] and muscle pain,[14] leading to its characterization as a "distressed personality."[11] In this study, Negative Affectivity has a significant positive predictive role for each dimension and the overall symptom level of GSRS in FGIDs patients. This suggests that as an individual's Negative Affectivity score increases, the severity of FGIDs symptoms (such as Indigestion, Diarrhea, Constipation, Abdominal Pain, Reflux) and the overall GSRS score also gradually rise, aligning with previous research findings.[10,13,36] Negative emotions may lead to physiological changes, such as alterations in intestinal motility or immune system regulation,[13,27] increasing the risk of FGIDs symptoms. Simultaneously, emotions can influence an individual's perception and coping with pain and discomfort,[37] further exacerbating the symptoms.

Our study found no significant impact of social inhibition on symptom manifestation in FGID patients. Although we observed a negative correlation between social inhibition and the abdominal pain dimension, its effect was relatively weak and did not significantly affect other GSRS dimensions. This may be due to the intricate relationship between social inhibition and negative emotions regulating emotions. Previous research has shown distinct neural activation patterns and mechanisms between negative emotions and social inhibition during emotion regulation.[38] Future studies could explore these differences further and investigate the precise role of social inhibition in FGID patients and its mechanisms in emotion regulation.

Relationship between emotion regulation strategies and GSRS in FGIDs patients

The analysis provided mixed results for the hypothesis regarding emotion regulation strategies. Research suggests positive emotion regulation strategies enhance mental and physical health, enabling effective stress coping.[18] In this study, Expressive Suppression positively predicts the overall level and all sub-dimensions of gastrointestinal symptoms in FGIDs patients. This aligns with James J. Gross's emotion regulation model,[39] indicating that emotion regulation during both the experience and expression stages significantly influences an individual's health and disease, depending on the employed emotion regulation strategies and their effectiveness. Expressive Suppression is a strategy involving attention to reactions, suppressing self-control during emotions that are about to occur or are occurring.[40] Studies by Brans et al.[41] suggest that attempting to inhibit or conceal emotional expression is generally considered to have a negative impact on emotional experience. As Expressive Suppression often aligns with internal emotional experiences, individuals still feel emotions, but they do not express them verbally or behaviorally.[42] This strategy leads to internal tension and repression of emotions as individuals must exert effort to inhibit the expression of emotions.[40] Over time, individuals inclined to use the Expressive Suppression strategy may change the neural systems

Table 5. Regression analysis of GSRS and its sub-dimensions on emotion regulation strategies

Dependent variable	Independent variable	R^2	Standardized coefficients	t	FDR p
Indigestion	Expressive Suppression	0.117	0.249	29.110**	0.005
	Cognitive Reappraisal		−0.088	−1.843	0.101
Diarrhea	Expressive Suppression	0.110	0.212	21.339*	0.007
	Cognitive Reappraisal		−0.070	−0.144	0.988
Constipation	Expressive Suppression	0. 126	0.280	33.785***	<0.001
	Cognitive Reappraisal		−0.124	−2.594*	0.042
Abdominal Pain	Expressive Suppression	0. 232	0.279	38.768***	<0.001
	Cognitive Reappraisal		−0.176	−31.696***	<0.001
Reflux	Expressive Suppression	0. 012	0.035	0.937	0.462
	Cognitive Reappraisal		−0.050	−1.044	0.104
GSRS	Expressive Suppression	0.181	0.251	40.279***	<0.001
	Cognitive Reappraisal		−0.083	−2.350*	0.048

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

associated with emotions and stress responses.[43] Research indicates that prolonged emotional suppression may lead to increased stress hormones such as cortisol,[44] enhanced sympathetic nervous system activity,[24] decreased frontal lobe activity, and increased amygdala activity.[45] These physiological changes may be related to alterations in the brain-gut axis, subsequently influencing gastrointestinal function and health.

Conversely, the Cognitive Reappraisal strategy has a significant negative predictive effect on Constipation, Abdominal Pain, and the total GSRS score. This suggests that as the use of Cognitive Reappraisal increases, FGIDs patients experience a gradual decrease in symptom severity in these dimensions and overall GSRS levels, indicating higher levels of health. This implies that patients employing cognitive reappraisal more effectively alleviate these symptoms, or these strategies aid in coping with and mitigating the negative impact of symptoms. This result aligns with Gross's emotion regulation theory,[20] where cognitive reappraisal is considered a leading emotion regulation strategy.[18] By changing their cognition of events before the onset of emotions, individuals can reduce the input of negative emotional experiences and positively predict mental and physical health.[23] However, due to the prolonged use of negative emotion regulation strategies among FGIDs patients, leading to functional changes at the cognitive level, they are accustomed to adopting negative coping mechanisms for life stressors and negative events.[13] Consequently, the application of Cognitive Reappraisal in FGIDs patients is reduced, and its predictive effect on other GSRS symptom dimensions is insignificant.

Notably, the Reflux sub-dimension is not significantly influenced by the Expressive Suppression strategy, and Cognitive Reappraisal also has no significant predictive effect. This may suggest that these two emotion regulation strategies have no pronounced impact on the expression of Reflux symptoms or that the pathogenesis of Reflux is less related to emotion regulation strategies.

All in all, this study uncovers significant influences of gender and age on gastrointestinal symptoms among FGID patients. Specifically, Negative Affectivity emerges as a key predictor, positively impacting the severity of gastrointestinal symptoms in FGID patients. Conversely, Social Inhibition exhibits a notable negative correlation with Abdominal Pain. The expressive suppression strategy emerges as a positive predictor, indicating heightened overall gastrointestinal symptoms and their sub-dimensions in FGID patients. On the contrary, the cognitive reappraisal strategy significantly predicts lower levels of Constipation, Abdominal Pain, and the total GSRS score. In summary, gender, age, type D personality traits, and emotion regulation strategies all assume pivotal roles in the initiation and manifestation of FGIDs symptoms. These discoveries enhance comprehension of the intricacies and individual variations in FGIDs, providing valuable insights for pertinent clinical diagnosis and treatment. Further investigation is imperative to investigate these correlations and potential mechanisms, offering scientifically sound recommendations for clinical practice and intervention measures.

Limitations of the study

Firstly, our study was constrained by its cross-sectional design, limiting our ability to draw causal conclusions. Conducting longitudinal research in the future would help establish causal relationships. Secondly, data collection relied on self-report measures, which may have introduced response bias. Future studies could consider incorporating objective measures such as biomarkers to address this issue to gain deeper insights into the observed associations. Furthermore, integrating neuroimaging techniques like fMRI could shed light on the neural mechanisms underlying the relationship between FGID symptoms and negative emotions, thereby advancing our understanding of FGID.

STAR★METHODS

Detailed methods are provided in the online version of this paper and include the following:

- KEY RESOURCES TABLE
- RESOURCE AVAILABILITY
  - Lead contact

ACKNOWLEDGMENTS

The author thanks the Gastroenterology Department at the Second Affiliated Hospital of Guizhou University of TCM for their invaluable support and assistance throughout this research. Additionally, the author acknowledges the National Administration of Traditional Chinese Medicine's (NATCM) Project of Youth Qihuang Scholars (NATCM Personnel and Education Department, 2020, No. 7), NATCM's Project of High-level Construction of Key Traditional Chinese Medicine Disciplines (Project number: zyyzdxk-2023187), and the Key Laboratory of Translational Medicine for Disease Prevention and Treatment by combining TCM and Western Medicine (Qian Jiaoji [2023]017) for providing funds. This research would not have been possible without their generous contributions and guidance.

AUTHOR CONTRIBUTIONS

Z.H.X. conceived and designed the study. X.X.M. and W.C. performed the study and analyzed the data. S.Y.Z. collected the data and contributed materials. X.X.M. wrote the paper with input from all authors.

DECLARATION OF INTERESTS

The authors declare no conflicts of interest related to this research.

Received: October 11, 2023
Revised: April 1, 2024
Accepted: April 29, 2024
Published: April 30, 2024

REFERENCES

1. Black, C.J., Drossman, D.A., Talley, N.J., Ruddy, J., and Ford, A.C. (2020). Functional gastrointestinal disorders: advances in understanding and management. Lancet *396*, 1664–1674. https://doi.org/10.1016/S0140-6736(20)32115-2.
2. Huang, M.H., Wang, Y.P., Wu, P.S., Chan, Y.L.E., Cheng, C.M., Yang, C.H., Tsai, S.J., Lu, C.L., and Tsai, C.F. (2021). Association between gastrointestinal symptoms and depression among older adults in Taiwan: a cross-sectional study. J. Chin. Med. Assoc. *84*, 331–335. https://doi.org/10.1097/JCMA.0000000000000460.
3. Narayanan, S.P., Anderson, B., and Bharucha, A.E. (2021). Sex-and gender-related differences in common functional gastroenterologic disorders. Mayo Clin. Proc. *96*, 1071–1089. https://doi.org/10.1016/j.mayocp.2020.10.004.
4. Chang, L., Toner, B.B., Fukudo, S., Guthrie, E., Locke, G.R., Norton, N.J., and Sperber, A.D. (2006). Gender, age, society, culture, and the patient's perspective in the functional gastrointestinal disorders. Gastroenterology *130*, 1435–1446. https://doi.org/10.1053/j.gastro.2005.09.071.
5. Houghton, L.A., Heitkemper, M., Crowell, M., Emmanuel, A., Halpert, A., McRoberts, J.A., and Toner, B. (2016). Age, gender, and women's health and the patient. Gastroenterology *150*, 1332–1343.e4. https://doi.org/10.1053/j.gastro.2016.02.017.
6. Ghoshal, U.C., and Singh, R. (2017). Frequency and risk factors of functional gastro-intestinal disorders in a rural Indian population. J. Gastroenterol. Hepatol. *32*, 378–387. https://doi.org/10.1111/jgh.13465.
7. Fagherazzi, G., Gusto, G., Balkau, B., Boutron-Ruault, M.C., Clavel-Chapelon, F., and Bonnet, F. (2016). Functional gastrointestinal disorders and incidence of type 2 diabetes: Evidence from the E3N–EPIC cohort study. Diabetes Metab. *42*, 178–183. https://doi.org/10.1016/j.diabet.2015.11.006.
8. Ålander, T., Svärdsudd, K., and Agréus, L. (2008). Functional gastrointestinal disorder is associated with increased non-gastrointestinal healthcare consumption in the general population. Int. J. Clin. Pract. *62*, 234–240. https://doi.org/10.1111/j.1742-1241.2007.01549.x.
9. Denollet, J. (2005). DS14: standard assessment of negative affectivity, social inhibition, and Type D personality. Psychosom. Med. *67*, 89–97. https://doi.org/10.1097/01.psy.0000149256.81953.49.
10. Hansel, S.L., Umar, S.B., Lunsford, T.N., Harris, L.A., Dibaise, J.K., and Crowell, M.D. (2010). Personality traits and impaired health-related quality of life in patients with functional gastrointestinal disorders. Clin. Gastroenterol. Hepatol. *8*, 220–222. https://doi.org/10.1016/j.cgh.2009.10.008.
11. Denollet, J. (2000). Type D personality: A potential risk factor refined. J. Psychosom. Res. *49*, 255–266. https://doi.org/10.1016/S0022-3999(00)00177-X.
12. Pedersen, S.S., and Denollet, J. (2003). Type D personality, cardiac events, and impaired quality of life: a review. Eur. J. Cardiovasc. Prev. Rehabil. *10*, 241–248. https://doi.org/10.1097/00149831-200308000-00005.
13. Jordi, S.B.U., Botte, F., Lang, B.M., Greuter, T., Krupka, N., Auschra, B., Schreiner, P., Sulz, M.C., Biedermann, L., von Känel, R., et al. (2021). Type D personality is associated with depressive symptoms and clinical activity in inflammatory bowel disease. Aliment. Pharmacol. Ther. *54*, 53–67. https://doi.org/10.1111/apt.16365.
14. Condén, E., Leppert, J., Ekselius, L., and Åslund, C. (2013). Type D personality is a risk factor for psychosomatic symptoms and musculoskeletal pain among adolescents: a cross-sectional study of a large population-based cohort of Swedish adolescents. BMC Pediatr. *13*, 1–9. http://www.biomedcentral.com/1471-2431/13/11.
15. Mols, F., and Denollet, J. (2010). Type D personality in the general population: a systematic review of health status, mechanisms of disease, and work-related problems. Health Qual. Life Outcomes *8*,

9–10. https://link.springer.com/article/10.1186/1477-7525-8-9.
16. Mols, F., and Denollet, J. (2010). Type D personality among noncardiovascular patient populations: a systematic review. Gen. Hosp. Psychiatry *32*, 66–72. https://doi.org/10.1016/j.genhosppsych.2009.09.010.
17. Bartels, H., Pedersen, S.S., van der Laan, B.F.A.M., Staal, M.J., Albers, F.W.J., and Middel, B. (2010). The impact of Type D personality on health-related quality of life in tinnitus patients is mainly mediated by anxiety and depression. Otol. Neurotol. *31*, 11–18. https://doi.org/10.1097/mao.0b013e3181bc3dd1.
18. Gross, J.J. (1998). The emerging field of emotion regulation: An integrative review. Rev. Gen. Psychol. *2*, 271–299. https://doi.org/10.1037/1089-2680.2.3.271.
19. Gross, J.J., Richards, J. M., and John, O. P. (2006). Emotion Regulation in Everyday Life. https://doi.org/10.1037/11468-001.
20. Gross, J.J. (2002). Emotion regulation: Affective, cognitive, and social consequences. Psychophysiology *39*, 281–291. https://doi.org/10.1017/S0048577201393198.
21. Dryman, M.T., and Heimberg, R.G. (2018). Emotion regulation in social anxiety and depression: A systematic review of expressive suppression and cognitive reappraisal. Clin. Psychol. Rev. *65*, 17–42. https://doi.org/10.1016/j.cpr.2018.07.004.
22. Dennis, T.A. (2007). Interactions between emotion regulation strategies and affective style: Implications for trait anxiety versus depressed mood. Motiv. Emot. *31*, 200–207. https://doi.org/10.1007/s11031-007-9069-6.
23. Troy, A.S., Shallcross, A.J., Brunner, A., Friedman, R., and Jones, M.C. (2018). Cognitive reappraisal and acceptance: Effects on emotion, physiology, and perceived cognitive costs. Emotion *18*, 58–74. https://doi.org/10.1037/emo0000371.
24. Traue, H.C., Kessler, H., and Deighton, R.M. (2016). Emotional inhibition. In Stress: Concepts, cognition, emotion, and behavior, pp. 233–240. https://doi.org/10.1016/B978-0-12-800951-2.00028-5.
25. Markus, H.R., and Kitayama, S. (2010). Cultures and selves: A cycle of mutual constitution. Perspect. Psychol. Sci. *5*, 420–430. https://doi.org/10.1177/1745691610375557.
26. Svedlund, J., Sjödin, I., and Dotevall, G. (1988). GSRS—a clinical rating scale for gastrointestinal symptoms in patients with irritable bowel syndrome and peptic ulcer disease. Dig. Dis. Sci. *33*, 129–134. https://doi.org/10.1007/bf01535722.
27. Xiaonan, Y., and Jianxin, Z. (2006). Application of Type D Personality Scale (DS14) in Chinese College Students. Chin. Ment. Health J. 313–316. http://tsweb.lib.gznu.edu.cn/https/vpn/33/NNYHGLUDN3WXTLUPMW4A/KXReader/Detail?invoice=HF0ytaE7GXhZmFqpfTD0jNfDifwV7opWp/qe5cq5kKx7IX8EkHFZVd7s3jZl2hPwvOa9fiqRHbJDFDbD0cet0%2BhbCzzfrCXW9mOZ83yDbr01zTlMdufa6vPGcmCYJJdwu3cTVqQN4KRQB6R9FWBV6Kpx21odDDN4f0nLxLXj52o%3D&DBCODE=CJFQ&FileName=ZXWS200605011&TABLEName=cjfd2006&nonce=2297C86DD4634A06AC24F839ED4ABFD0&TIMESTAMP=1712886511049&uid=.
28. Wei, C., Zhang, G., Tian, X., Luo, J., Gao, R., and Yang, T. (2020). Test of the Emotion Regulation Questionnaire in the middle school students, *34*, pp. 206–211. http://tsweb.lib.gznu.edu.cn/https/vpn/33/NNYHGLUDN3WXTLUPMW4A/KXReader/Detail?invoice=QeNuTotNn6ePa53t2BG5lIc0rpokFcsWuDKjlGvF2cHzlAlO2srF2ntC7ZpHP3gCt51pvxoNAHjTEkWyRdDmauO6WHee5K8wBOdJlAQvJFPYLWzp8cz0rPYqOqdwJW5N3FQzHyHoN72C1Zp7DsWSl9%2Bki1HmTjoeDG3ieN%2Bcgf0%3D&DBCODE=CJFQ&FileName=ZXWS202003011&TABLEName=cjfdlast2020&nonce=60A3B286C8824937A2B69B5F80006086&TIMESTAMP=1712886916906&uid=.
29. Fukudo, S., Ida, M., Akiho, H., Nakashima, Y., and Matsueda, K. (2014). Effect of ramosetron on stool consistency in male patients with irritable bowel syndrome with diarrhea. Clin. Gastroenterol. Hepatol. *12*, 953–959.e4. https://doi.org/10.1016/j.cgh.2013.11.024.
30. Yueh, T.P., Chen, F.Y., Lin, T.E., and Chuang, M.T. (2014). Diarrhea after laparoscopic cholecystectomy: associated factors and predictors. Asian J. Surg. *37*, 171–177. https://doi.org/10.1016/j.asjsur.2014.01.008.
31. Huang, D.B., Sanchez, A.P., Triana, E., Jiang, Z.D., DuPont, H.L., and Ericsson, C.D. (2004). United States male students who heavily consume alcohol in Mexico are at greater risk of travelers' diarrhea than their female counterparts. J. Travel Med. *11*, 143–145. https://doi.org/10.2310/7060.2004.18560.
32. Jang, D.E., Bae, J.H., Chang, Y.J., Lee, Y.H., Nam, K.T., Kim, I.Y., Seong, J.K., Lee, Y.C., and Yeom, S.C. (2018). Neuronal nitric oxide synthase is a novel biomarker for the interstitial cells of Cajal in stress-induced diarrhea-dominant irritable bowel syndrome. Dig. Dis. Sci. *63*, 619–627. https://doi.org/10.1007/s10620-018-4933-7.
33. Ho, D.Y. (2013). Fatherhood in Chinese culture. In The father's role (Routledge), pp. 227–245. eBook: ISBN9780203761526.
34. Liebman, M., Propst, K., Moore, S.A., Pelican, S., Holmes, B., Wardlaw, M.K., Melcher, L.M., Harker, J.C., Dennee, P.M., and Dunnagan, T. (2003). Gender differences in selected dietary intakes and eating behaviors in rural communities in Wyoming, Montana, and Idaho. Nutr. Res. *23*, 991–1002. https://doi.org/10.1016/S0271-5317(03)00080-0.
35. Hwang, U., Belland, L.K., Handel, D.A., Yadav, K., Heard, K., Rivera-Reyes, L., Eisenberg, A., Noble, M.J., Mekala, S., Valley, M., et al. (2014). Is all pain is treated equally? A multicenter evaluation of acute pain care by age. Pain *155*, 2568–2574. https://doi.org/10.1016/j.pain.2014.09.017.
36. Zimmer, Z., Fraser, K., Grol-Prokopczyk, H., and Zajacova, A. (2022). A global study of pain prevalence across 52 countries: examining the role of country-level contextual factors. Pain *163*, 1740–1750. https://doi.org/10.1097/j.pain.0000000000002557.
37. Bashashati, M., Sarosiek, I., and McCallum, R.W. (2016). Epidemiology and mechanisms of gastroesophageal reflux disease in the elderly: a perspective. Ann. N. Y. Acad. Sci. *1380*, 230–234. https://doi.org/10.1111/nyas.13196.
38. Lee, J., Anggiansah, A., Anggiansah, R., Young, A., Wong, T., and Fox, M. (2007). Effects of age on the gastroesophageal junction, esophageal motility, and reflux disease. Clin. Gastroenterol. Hepatol. *5*, 1392–1398. https://doi.org/10.1016/j.cgh.2007.08.011.
39. Sharbafchi, M.R., Tabatabaiyan, S., Haghighatdoost, F., Afshar, H., Keshteli, A.H., Feizi, A., Moghtadaee, K., Roohafza, H.R., and Adibi, P. (2020). Personality traits are related to functional dyspepsia in a large sample of Iranian adults. J. Psychosom. Res. *129*, 109912. https://doi.org/10.1016/j.jpsychores.2019.109912.
40. Amaro-Díaz, L., Montoro, C.I., Fischer-Jbali, L.R., and Galvez-Sánchez, C.M. (2022). Chronic pain and emotional stroop: a systematic review. J. Clin. Med. *11*, 3259. https://doi.org/10.3390/jcm11123259.
41. Kret, M.E., Denollet, J., Grèzes, J., and de Gelder, B. (2011). The role of negative affectivity and social inhibition in perceiving social threat: an fMRI study. Neuropsychologia *49*, 1187–1193. https://doi.org/10.1016/j.neuropsychologia.2011.02.007.
42. Gross, J.J. (2015). The extended process model of emotion regulation: Elaborations, applications, and future directions. Psychol. Inq. *26*, 130–137. https://doi.org/10.1080/1047840X.2015.989751.
43. Gross, J.J., and John, O.P. (2003). Individual differences in two emotion regulation processes: implications for affect, relationships, and well-being. J. Pers. Soc. Psychol. *85*, 348–362. https://doi.org/10.1037/0022-3514.85.2.348.
44. Brans, K., Koval, P., Verduyn, P., Lim, Y.L., and Kuppens, P. (2013). The regulation of negative and positive affect in daily life. Emotion *13*, 926–939. https://doi.org/10.1037/a0032400.
45. Kalokerinos, E.K., Greenaway, K.H., and Denson, T.F. (2015). Reappraisal but not suppression downregulates the experience of positive and negative emotion. Emotion *15*, 271–275. https://doi.org/10.1037/emo0000025.
46. Benjamini, Y., and Yekutieli, D. (2001). The control of the false discovery rate in multiple testing under dependency. Ann. Statist. *29*, 1165–1188. https://www.jstor.org/stable/2674075.
47. Ekman, P. (1984). Expression and the Nature of Emotion. In Approaches to emotion, *3*Approaches to emotion, p. 344. https://sc.panda985.com/#v=onepage&q=Expression%20and%20the%20nature%20of%20emotion.&f=false.
48. Sher, L. (2005). Type D personality: the heart, stress, and cortisol. QJM *98*, 323–329. https://doi.org/10.1093/qjmed/hci064.
49. Delli Pizzi, S., Chiacchiaretta, P., Mantini, D., Bubbico, G., Ferretti, A., Edden, R.A., Di Giulio, C., Onofrj, M., and Bonanni, L. (2017). Functional and neurochemical interactions within the amygdala–medial prefrontal cortex circuit and their relevance to emotional processing. Brain Struct. Funct. *222*, 1267–1279. https://doi.org/10.1007/s00429-0161276-z.

STAR★METHODS

KEY RESOURCES TABLE

REAGENT or RESOURCE	SOURCE	IDENTIFIER
Software and algorithms		
Amos 24.0	IBM	https://www.ibm.com/support/pages/downloading-ibm-spss-amos-26
SPSS 23.0	IBM	https://www.ibm.com/support/pages/downloading-ibm-spss-statistics-23
False Discovery Rate (FDR) correction method	Benjamini et al.[46]	https://www.bioladder.cn/web/#/chart/58

RESOURCE AVAILABILITY

Lead contact

Further information and requests for resources should be directed to and will be fulfilled by the lead contact, Zheng-Hua Xiao (435204673@qq.com).

Materials availability

This study did not generate new unique reagents.

Data and code availability

- All data reported in this paper will be shared by the lead contact upon request.
- This paper does not report original code.
- Any additional information required to reanalyze the data reported in this paper is available from the lead contact upon request.

EXPERIMENTAL MODEL AND STUDY PARTICIPANT DETAILS

Study design

This research employed a cross-sectional questionnaire-based study design.

Participants and ethical review

Participants diagnosed with FGID were recruited from the gastroenterology outpatient department of the Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine. All the subjects were Chinese; they were invited to complete the questionnaire during their outpatient visits. A total of 1008 questionnaires were distributed to participants. After meticulous scrutiny and subsequent thorough review process to eliminate questionnaires with consistent patterns, perfunctory responses, or missing data, we retained 911 valid questionnaires for further analysis. This yielded a commendable effective response rate of 90.37%. Regarding age and gender assessment, participants self-reported their age and gender on the questionnaire. Additionally, age was confirmed through medical records for validation purposes. The gender distribution among participants comprised 399 males (40%) and 592 females (60%). Regarding comorbidities, participants were asked to indicate any other chronic health conditions they had been diagnosed with with in the questionnaire. Participants reported various comorbidities such as hypertension, coronary heart disease, and diabetes. However, conducting a detailed analysis of comorbidities was beyond the scope of this study and warranted further investigation in future studies. The mean age of the participants was 44.63 (SD = 16.96), with 418 participants aged 18–35 years (42.2%), 384 participants aged 36–60 years (38.7%), and 189 participants aged 60 years and above (19.1%).

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, and all participants have provided informed consent.

METHOD DETAILS

Research tools

Gastrointestinal Symptoms: The GSRS, developed by Svedlund et al.,[47] was utilized to evaluate gastrointestinal symptoms across five dimensions—indigestion, diarrhea, constipation, reflux, and abdominal pain—comprising a total of 15 items. Employing a Likert four-point scoring method, higher scores denoted greater symptom severity, while lower scores indicated better health. The GSRS exhibited high internal consistency in our study, as noted in a Cronbach's α coefficient of 0.87.

Type D Personality: To assess Type D personality, the DS-14, a scale developed by Denollet[9] and adapted into Chinese by Xiao Nan and Zhang Jianxin,[48] was employed. Comprising 14 items, the scale measures negative affectivity (NA) and social inhibition (SI), each represented

by seven items. NA items gauge emotions such as irritability, worry, and anger, while SI items assess behaviors including social restraint, discomfort in social situations, and a tendency to remain silent. Scores range from 0 (does not apply at all) to 4 (applies completely), with NA and SI subscales having a score range of 0–28. High internal consistency was observed in this study, with Cronbach's α coefficients of 0.82 and 0.85 for NA and SI subscales, respectively.

Emotion Regulation Strategies: In this study, the Chinese version of the Gross-John Emotion Regulation Questionnaire, revised by Chen Wei et al.[49] based on the original version by Gross et al.,[19] was utilized. It comprises two dimensions: cognitive reappraisal (items 1–6) and expressive suppression (items 7–10), totaling ten items. Responses were recorded on a 7-point rating scale (1 = strongly disagree, 7 = strongly agree), with higher scores indicating a greater tendency to adopt these strategies. Strong internal consistency was demonstrated, with Cronbach's α coefficients of 0.81 and 0.79 for the cognitive reappraisal and expressive suppression subscales, respectively.

Investigation phase

We utilized a questionnaire-based approach to enlist participants diagnosed with FGID from the gastroenterology outpatient department of the Second Affiliated Hospital of Guizhou University of Traditional Chinese Medicine. The questionnaire assessed various aspects of gastrointestinal symptoms, psychological factors, demographic information, and comorbidities.

Data Collection and Cleaning: A total of 1008 questionnaires were distributed to participants, and responses were collected during outpatient visits. During the data cleaning process, two doctoral students carefully reviewed each response during the data-cleaning process to identity and exclude those exhibiting regular patterns or omissions. After this meticulous scrutiny and subsequent thorough review process to eliminate questionnaires with consistent patterns, perfunctory responses, or missing data, we retained 911 valid questionnaires for further analysis.

Data analysis

Confirmatory factor analysis was conducted using Amos 24.0 to evaluate the fit of the measurement model and assess the relationships between observed variables and latent constructs.

Descriptive statistical analyses were performed using SPSS 23.0 to summarize the essential characteristics of the sample and the distribution of the data.

Difference testing was conducted to compare mean scores across different groups. Two-tailed tests were employed for hypothesis testing, and independent sample t-tests and analysis of variance (ANOVA) were used to compare mean differences in continuous variables.

Covariate control was implemented to ensure the accuracy and reliability of the results by controlling for confounding variables.

The False Discovery Rate (FDR) correction method[46] was applied to control the error rate associated with multiple comparisons. The Benjamini-Hochberg method-based FDR correction was used to adjust all test results, ensuring higher reliability and robustness of the research findings.

QUANTIFICATION AND STATISTICAL ANALYSIS

In this study, we employed the following analytical procedures to handle the data: Firstly, we utilized Amos 24.0 to conduct confirmatory factor analysis to assess the fit of the measurement model, ensuring that the measurement indicators accurately reflected latent variables. Subsequently, descriptive statistical analyses were performed using SPSS 23.0 to better understand the essential characteristics of the sample and the distribution of the data. Next, we conducted difference testing to compare the mean scores across different groups. Hypothesis testing was carried out using two-tailed tests to comprehensive evaluation the effects. To compare the mean differences in continuous variables, we opted for t-tests and analysis of variance (ANOVA). Considering the independence of samples, independent sample t-tests and ANOVA were employed. Covariate control was implemented to ensure the accuracy and reliability of the results in controlling for confounding variables. We used the False Discovery Rate (FDR) correction method to control the error rate associated with multiple comparisons. In this process, we initially established the original significance level (typically $p < 0.05$) and then applied the Benjamini-Hochberg method-based FDR correction to adjust all test results, controlling the actual level of significance discovered, thereby ensuring higher reliability and robustness of the research findings during multiple comparisons. Furthermore, Cronbach's α coefficient between 0.7 and 0.9 is generally considered optimal, indicating a high level of internal consistency within the scale.