

The Role of Emotion and its Regulation in Gluten-Free Diet Adherence Among Adults with Coeliac Disease

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Received: August 30, 2026; **Accepted:** September 09, 2026; **Published:** September 15, 2026

ABSTRACT

Objectives: Coeliac disease (CD) is an autoimmune condition affecting 1-2% of the population, requiring a lifelong gluten-free diet (GFD) to manage adverse health outcomes, though compliance varies [1,2]. Research links negative emotional states (ES) to poorer GFD adherence [3]. Few studies find negative ES mediating emotional CD perceptions and adherence, and one Australian study suggests emotion regulation as a moderator [4,5]. This study explores the interrelationships and predictive utility of emotional factors on GFD adherence in CD internationally.

Design: Quantitative, cross-sectional questionnaire.

Method: Participants (N=82) were adults with CD recruited via social-media. Measures included illness perceptions, emotion regulation, negative ES, emotional eating and GFD adherence [6-10]. Linear regression analyses assessed the predictive strength of emotional variables on GFD adherence. Mediation and moderation analyses examined the roles of negative ES, emotional eating, and emotion regulation on adherence.

Results: Depression significantly predicted GFD adherence, while anxiety and stress did not. Negative ES mediated negative illness perceptions, but emotional eating did not. Emotion regulation strategies did not individually moderate these relationships, but their combined effect was significant.

Conclusions: Depression predicts GFD adherence in CD, influenced by negative illness perceptions. These findings could inform psychological interventions targeting depression and emotional CD perceptions to enhance GFD adherence in CD populations. Future research should explore specific mechanisms that moderate this relationship.

Keywords: Coeliac Disease, Negative Emotional States, Emotional Eating, Emotional Representations, Emotional Regulation, Dietary Adherence

Introduction

Coeliac Disease

Coeliac disease (CD) is an immune-mediated enteropathy triggered by gluten in genetically susceptible individuals, present in wheat, rye, barley, and oats [11]. More prevalent in women (2:1), CD affects 1-2% of the population with geographic variability [1]. Its global incidence is rising, positioning it as one of the most prevalent lifelong autoimmune disorders related to food [12,11].

Gluten consumption triggers an immune response in CD, damaging the small intestine's villi crucial for nutrient absorption

[12]. Symptoms range from malabsorption to asymptomatic cases, including diarrhoea, vomiting, and abdominal discomfort [13]. Though long-term complications are relatively rare, untreated CD can sustain symptoms and increase the susceptibility to cancers, neurological disorders, osteoporosis, and infertility [14,15].

Gluten-Free Diet

The only effective treatment for CD is a strict, lifelong gluten-free diet (GFD), involving complete avoidance of gluten to manage symptoms and reverse CD-related abnormalities [10]. Clinical studies show symptom resolution and improvement with a GFD, and long-term adherence maintains these benefits, making it the cornerstone of CD treatment [16-18]. Adherence rates vary widely, from 45% to 90%, influenced by dietary knowledge, and social and psychological challenges [19-22]. With the increasing

Citation: Alice Owen, Amy Baraniak, Paul Staples. The Role of Emotion and its Regulation in Gluten-Free Diet Adherence Among Adults with Coeliac Disease. Open Access J Pharma Sci and Drug. 2026. 2(3): 1-11. DOI: doi.org/10.61440/OAJPSD.2026.v2.53

prevalence of CD, understanding and promoting GFD adherence is crucial, highlighting its significance in research.

Despite initial health improvements in CD within months of starting a GFD, the ongoing effort to avoid gluten is challenging, disrupting lifestyle, relationships, and overall quality of life (QOL) [22]. Few studies suggest improved psychological well-being on GFDs, yet their long-term sustainability remains overlooked [23]. Adherence to GFDs and QOL in CD is complex, and influenced by psychosocial factors such as workplace challenges, travel, and social pressures [24-26]. Limited gluten-free options, high costs, and the risk of inadvertent gluten exposure further hinder adherence [27,22].

Literature reviews show that longer compliance with GFDs correlates with sustained psychological burdens, underscoring the need for effective emotional support interventions [65,66]. While cognitive and sociocultural factors are well-studied, emotional factors are often neglected [22]. This study examines the impact of emotional factors on GFD adherence.

Emotional States

Emotion has been shown to negatively impact treatment compliance in conditions such as diabetes and cancer [28]. Similarly, in CD, research links negative emotional states (ES), specifically anxiety and depression, to poorer GFD adherence [16,29-33]. According to Leventhal's Self-Regulatory Model, critical emotional factors include perceptions of illness, encompassing emotions like fear and acceptance [34]. This association has been observed in CD populations, with research finding that negative CD-related perceptions correlated with more adverse ES among GFD adherents, though it lacked a validated measure of GFD adherence [35]. Research replicated this study using validated measures, finding that depression partially mediates the relationship between emotional representations of CD and GFD adherence [5]. More recent findings highlight a significant link between negative CD-related perceptions and reduced motivation for GFD adherence, due to depression stemming from social pressures associated with gluten consumption [4]. However, this study exclusively examined depression and did not encompass other emotive states. Thus, further investigation is needed to confirm the broader mediating influence of negative ES. Based on the literature, it is hypothesised that negative ES, particularly depression and anxiety, significantly explain variations in GFD adherence and mediates the relationship between emotional perceptions of CD and GFD adherence.

Emotional Eating

Emotional eating (EE) involves food consumption in response to negative emotions, independent of physiological hunger, and is linked to health complications [36]. Recent studies have established a strong connection between binge eating and negative ES, often associated with disordered eating behaviours [37]. In CD, dietary management is pivotal, and eating patterns significantly influence adherence [66]. Therefore, investigating EE as a factor of GFD adherence in CD populations is pertinent. Given the likelihood of experiencing negative emotions due to CD and the observed relationship between negative ES and increased EE, it seems reasonable to assume that CD individuals may be more susceptible to EE behaviours [3,37].

To date, only one study has examined EE in GFD adherence, finding no significant correlation, indicating a need for further research. A recent systematic review and meta-analysis reported a high prevalence of eating disorders among CD individuals (8.88%) [5,31]. Given that CD populations exhibit high rates of disordered eating, and that EE is associated with increased use of expressive suppression (Arigo et al., 2012), it is plausible that individuals who struggle with negative perceptions of CD may engage in EE [31]. Thus, in addition to negative ES, it is hypothesised that EE serves as a proximal predictor of GFD adherence and mediates the relationship between emotional perceptions of CD and GFD adherence.

Emotion Regulation

Effective coping strategies are essential for navigating challenges in adhering to a GFD, which demands lifelong adjustments such as careful food label reading, safe food preparation, and advocating for dietary needs to avoid cross-contamination [38,39]. Past research has predominantly focused on practical coping strategies like food label interpretation and gluten exposure prevention [40,41]. While these strategies address practical issues, managing emotional challenges necessitates more focus on emotional regulation, an area less explored in GFD adherence research [39]. This study aims to explore strategies for managing emotional challenges in CD, informing the development of interventions to enhance GFD adherence. Drawing from insights by Ford et al. and Kerswell & Strodl, the study hypothesises that addressing negative ES and coping with illness representations are critical intervention targets [42,35,5].

Emotion regulation involves processes that modify emotional reactions to enhance, maintain, or reduce their components [7]. While its role in dietary adherence is underexplored, strategies like cognitive reappraisal and expressive suppression are commonly used [43,44]. Reappraisal alters emotional impact by reframing situations, promoting positive emotions and reducing negative ones [45]. It correlates with better emotion management, functioning, and well-being over time, proving more effective than suppression in moderating emotional intensity and behavioural expressions [46]. Suppression inhibits both the experience and expression of emotions, linked to poorer psychological outcomes [47,48]. Individual differences in emotion management strategies among individuals with CD may consequently account for variations in emotional adjustment to living with CD and forming emotional perceptions. One study found these strategies moderated the link between emotional perceptions of CD and depression in an Australian sample [36]. This study aims to replicate and expand on this work internationally to further understand the complex interplay between emotion regulation strategies and GFD adherence in individuals with CD. Based on existing literature, it is anticipated that the relationship between emotional perceptions of CD and negative ES will be moderated by emotion regulation strategies, with higher levels of reappraisal buffering the impact.

Study Aims

The overarching aim of this study is to explore the interrelationships and predictive utility of a range of psychological variables on GFD adherence in CD, which will be explored in relation to three research questions. Firstly, how do negative ES, EE, and adherence to GFDs interrelate among adults with CD? This will be

met by testing the first hypothesis that negative ES and increased EE will predict GFD adherence. Secondly, what is the mediating role of negative ES and increased EE in the relationship between emotional perceptions of CD and adherence to a GFD? This will be met by testing the second hypothesis that negative ES and EE mediate the relationship between emotional perceptions of CD and GFD adherence. Lastly, to what extent do emotion regulation strategies, specifically reappraisal and suppression, moderate the baseline relationship between emotional perceptions of CD and negative ES? This will be met by testing the third hypothesis that emotional regulation strategies would moderate the relationship between emotional perceptions of CD and negative ES, with higher levels of reappraisal buffering the impact.

Method

Design and Procedure

The study employed a quantitative, cross-sectional questionnaire design to investigate baseline relationships, as well as mediating and moderating relationships, between emotional factors and GFD adherence.

Prospective participants were recruited via social media channels following appropriate permissions. The recruitment advertisement included a concise overview of the study and a hyperlink to Qualtrics, which hosted a participant information sheet detailing the study's focus, participation requirements, data handling procedures, participant rights, and contact information for inquiries. After obtaining informed consent, participants were directed to complete a series of questionnaires. Demographic information was collected, followed by randomised presentation of the questionnaire measures. Upon completion, participants viewed a debriefing page that included appropriate signposting and a reminder of their rights throughout the research process.

Participants

Eligible participants were adults aged 18 and above, English-speaking, and diagnosed with CD for at least six months. Individuals under 18, non-English speakers, or those diagnosed with CD for less than six months were excluded. These criteria ensured autonomy in dietary choices, effective communication, and experience with GFDs [Table 1].

Table 1: Participant Inclusion and Exclusion Criteria with Justifications

Type of Criteria	Criteria Details	Reasoning for Criteria
Inclusion	- Age 18 years and above - Fluent in English - Minimum of 6-month Diagnosis of Coeliac Disease	Ensures autonomy in dietary choices and valuable insights. Ensures accurate comprehension and reliable data. Focuses on those managing Coeliac Disease with experience in adherence to a gluten-free diet.
Exclusion	- Under 18 years of age - Lack of fluency in English - Less than a 6-month Diagnosis of Coeliac Disease	Focuses on adult experiences, which differ from those of minors, and avoids ethical and legal complexities in obtaining consent from minors. Prevents language barriers affecting data reliability. Ensures sufficient time for adjustment to a gluten-free diet.

The final sample included 82 participants from the initial 151 who consented, met eligibility criteria and completed demographic information. A total of 69 participants (54.3%) dropped out, with 63 discontinuing during the completion of psychometric measurements. Following ethical approval requirements, participants who did not complete one or more items across all scales were considered withdrawn, accounting for the final 6 exclusions.

An a priori power analysis using G*Power version 3.1.9.7 estimated sample size based on Kerswell and Strodl's study (N= 253), finding an effect size of .286, which is considered medium by Cohen's criteria [50,5,51]. With a significance criterion of $\alpha = .05$ and power = .80, a minimum sample size of N= 64 was required to achieve adequate statistical power. The obtained sample size of N= 82 is more than adequate to test the study hypotheses.

Materials

Participants completed online questionnaires, requiring access to an electronic device and the internet. Initially, demographic information (age, assigned sex, gender identification, country of residence, ethnicity, socioeconomic status, and disabilities) was collected to ensure sample diversity. Questionnaire measures were administered in a randomised order to minimise order effects.

Measures

The Emotional Wellbeing: Depression, Anxiety, and Stress Scale (DASS-21)

The DASS-21 is a validated 21-item measure assessing depression, anxiety, and stress. Participants rate each item on a four-point scale (0= did not apply to 3= applied most of the time) [8]. Scores are totalled to produce separate scores for depression, anxiety, and stress, with higher scores indicating more severe symptoms. Depression scores range from normal (0-9) to extremely severe (28+), anxiety scores range from normal (0-7) to extremely severe (20+), and stress scores range from normal (0-14) to extremely severe (34+) [Table 2]. Cronbach's Alpha coefficients demonstrate excellent-to-good reliability across the subscales: depression ($\alpha=.93$), stress ($\alpha=.90$), anxiety ($\alpha=.77$) [5].

Table 2: Scoring Breakdown for the Emotional Well-Being: Depression, Anxiety, and Stress Scale (DASS-21)

NES Symptom Severity	Scores for DASS-21 Subscale		
	Depression	Anxiety	Stress
Normal	0-9	0-7	0-14
Mild	10-13	8-9	15-19
Moderate	14-20	10-14	19-25

Severe	21-27	15-19	26-33
Extremely severe	28+	20+	34+

Note: NES = Negative Emotional States; Adapted from Manual for the Depression Anxiety Stress Scales, by Lovibond, S.H. & Lovibond, P.F. (1995). (2nd Ed.) Sydney: Psychology Foundation

Emotional Eating Scale (EES)

The EES is a validated 25-item questionnaire assessing individuals' tendencies toward EE behaviours. It evaluates the extent to which eating serves as a coping mechanism for negative emotions [9]. Participants rate each item on a five-point Likert scale (1= no desire to eat, to 5= overwhelming urge to eat). Total scores indicate overall EE tendencies, with higher scores indicating greater inclinations toward EE. The subscales demonstrate excellent-to-good reliability: depression ($\alpha=.92$), boredom ($\alpha=.91$), anger and anxiety ($\alpha=.88$) [5].

Illness Perception Questionnaire-Revised (IPQ-R)

The IPQ-R is a validated tool used to assess individuals' perceptions of illness in Leventhal's Self-regulatory Model [6,34]. This study focuses on the revised version including a six-item emotional representations subscale, which evaluates participants' symptoms, causes, and perspectives. Responses are recorded on a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree), with higher scores indicating higher negative representations. The emotional representation subscale demonstrates good reliability ($\alpha=.89$) [5].

Coeliac Disease Adherence Test (CDAT)

The CDAT is a validated seven-item questionnaire designed to assess GFD adherence among individuals with CD [10]. Responses are rated on a five-point Likert scale, with varying response labels depending on the question syntax. Higher CDAT scores indicate poorer adherence to GFD guidelines, categorised as excellent-to-very-good (7-22), moderate (13-17), and fair-to-poor (18-35) [Table 3]. The scale demonstrates acceptable reliability ($\alpha=.72$) [52].

Table 3: Scoring Breakdown for the Coeliac Disease Adherence Test (CDAT)

GFD Adherence	CDAT Score
Excellent/Very Good	7-12
Moderate	13-17
Fair-to-poor	14-20

Note: GFD = Gluten-free Diet; Adapted from A simple validated gluten-free diet adherence survey for adults with coeliac disease, by Leffler et al., (2009)

Emotional Regulation Questionnaire (ERQ)

The ERQ is a validated 10-item tool assessing emotion regulation strategies: cognitive reappraisal and expressive suppression [7]. Responses use a seven-point Likert scale from 'Strongly Disagree' to 'Strongly Agree.' Higher scores indicate stronger engagement in these strategies. The scales demonstrate good-to-acceptable consistency: reappraisal ($\alpha=.89$), suppression ($\alpha=.76$) [7].

Ethics

In adherence to the British Psychological Society's Code of

Human Research Ethics (this research process was guided by several ethical considerations and received approval from the College of Health, Psychology and Social Care Research Ethics Committee at the University of Derby (Approval number: ETH2324-2612) [53].

Data Analysis

Data analysis utilised IBM SPSS Statistics. Initial steps included screening for outliers, assessing normality, and checking for multicollinearity. Missing data were imputed as necessary. Descriptive statistics summarised participant and variable characteristics. Inferential analyses tested hypotheses and relationships ($p < 0.05$).

Hypothesis one utilised simple and multiple linear regression, along with bivariate correlations, to explore baseline relationships. Predictor variables were negative ES and EE tendencies [8,9]. The outcome variable was GFD adherence [10].

Hypothesis two employed mediation analysis to investigate mediation effects using SPSS (version 26) with the PROCESS v4.2 regression macro extension, enabling bootstrapping for robust sampling distribution estimates [54-56]. The predictor variable was emotional representations, the outcome variable was GFD adherence (CDAT; Leffler et al., 2009), and the mediator variable included retained predictors of diet adherence identified in hypothesis one [6]. Hypothesis three examined moderation analysis via PROCESS to explore moderation effects. The predictor variable was emotional representations, the outcome variable included predictors of diet adherence retained from previous hypotheses, and the moderator variable was emotional regulation strategies [56,6,7].

Results

The final sample comprised 82 participants, aged 19 to 65 years ($M=36.6$, $SD=12.08$). The majority were female (79.3%), with varied gender identifications (Female=74.4%, Male=19.5%, Nonbinary=2.4%, Prefer not to say=3.7%). Participants resided in diverse countries (United Kingdom=26.8%, United States=37.8%, Canada=8.5%, Australia=4.9%, Ireland=8.9%, Other=12.2%), representing various ethnicities (White/Caucasian=91.5%, Hispanic/Latino=4.9%, Asian=2.4%, Other=1.2%).

Socioeconomic status varied (Low-income=24.4%, Medium-income=50%, High-income=25.6%), and 26.8% reported at least one comorbid disability [Table 4].

Reliability analyses using Cronbach's alpha were conducted for all questionnaire measures to assess internal consistency [Table 5]. Initial data screening ensured dataset quality. Little's MCAR test indicated no missing values. Preliminary tests raised concerns about CDAT skewness and kurtosis and EES skewness. Most z-scores fell within -1.96 to +1.96, indicating no significant deviations from normality. Shapiro-Wilk and Kolmogorov-Smirnov tests indicated non-normal distributions for CDAT, DASS-21, and EES. Outliers were retained to analyse significant individual differences [57]. A correlation table explored bivariate relationships between variables [Table 6].

Table 4: Participant Demographics

Demographic Variable	Sample N = 82 (%)
Gender Assigned at Birth	17 (20.7%)
Male Female	65 (79.3%)
Gender Identification	16 (19.5%)
Male Female Non-Binary	61 (74.4%)
Prefer not to say	2 (2.4%)
	3 (3.7%)
Country of Residence	22 (26.8%)
United Kingdom United States	31 (37.8%)
Canada Australia Ireland	7 (8.5%)
Other	4 (4.9%)
	8 (8.9%)
	10 (12.2%)
Ethnicity	75 (91.5%)
White/Caucasian Hispanic/Latino	4 (4.9%)
Asian	2 (2.4%)
Other	1 (1.2%)
Age	M = 36.6 SD = 12.08 Age Range = 19-65
Comorbid Disability	22 (26.8%)
Present Not-present	60 (73.2%)

Socioeconomic Status	20 (24.4%)
Low-income Medium-income High-income	41 (50%)
	21 (25.6%)

Table 5: Reliability coefficients for Subscales of all Measures

Measure and Subscale	Number of items	Cronbach's alpha
DASS-21	21	.94
Total Scale Depression	7	.93
Anxiety	7	.83
Stress	7	.89
EES	25	.94
Total scale		
IPQ-R	6	.65
Emotional Representations		
CDAT	7	.63
Total scale		
ERQ	10	.77
Total scale Reappraisal	6	.9
Suppression	4	.82

Note. * $p < .0001$; DASS, Depression Anxiety Stress Scale; EES, Emotional Eating Scale; IPQ-R, Illness Perception Questionnaire – Revised; CDAT, Coeliac Dietary Adherence Test; ERQ, Emotion Regulation Questionnaire.

Table 6: Bivariate Correlations for Surveys and Subscales

Variables	CDAT	IPQR	ERQ	Reappraisal	Suppression	DASS	Depression	Anxiety	Stress	EES
CDAT	-	.385**	-.165	-.324**	.135	.614**	.622**	.462**	.530**	.139
IPQR	.385**	-	.130	-.129	.360**	.538**	.443**	.474**	.513**	.121
ERQ	-.165	.130	-	.768**	.630**	-.039	-.070	.015	-.039	.025
Reappraisal	-.324**	-.129	.768**	-	-.013	-.256*	-.351**	-.138	-.171	-.077
Suppression	.135	.360**	.630**	-.013	-	.249*	.316**	.191	.146	.131
DASS	.614**	.538**	-.039	-.256*	.249*	-	.859**	.880**	.916**	.232*
Depression	.622**	.443**	-.070	-.351**	.316**	.859**	-	.592**	.652**	.263*
Anxiety	.462**	.474**	.015	-.138	.191	.880**	.592**	-	.787**	.192
Stress	.530**	.513**	-.039	-.171	.146	.916**	.652**	.787**	-	.157
EES	.139	.121	.025	-.077	.131	.232*	.263*	.192	.157	-

Note: Total, N = 82, ** $p < .001$, * $p < .05$; CDAT, Coeliac Dietary Adherence Test; IPQ-R, Illness Perception Questionnaire – Revised; ERQ, Emotion Regulation Questionnaire; DASS, Depression Anxiety Stress Scale; EES, Emotional Eating Scale.

Baseline Relationships

Regression analyses were conducted to test the first hypothesis that negative ES and EE predict GFD adherence. EE was excluded from the analysis as an initial correlation matrix indicated there were no significant bivariate correlations with GFD adherence ($r(80) = .139$, $p = .212$, two-tailed). There was a significant, strong, positive correlation between poorer GFD adherence and negative ES ($r(80) = .614$, $p < .001$, two-tailed), indicating that higher negative ES correspond to poorer GFD adherence. Therefore, DASS-21 was retained for further analysis.

A simple linear regression analysis was conducted to assess the predictive power of DASS-21 on CDAT scores [Table 7]. Assumptions for regression analysis were met; scatterplot analyses confirmed homoscedasticity between DASS-21 and CDAT scores, and examination of standardised residuals' histogram indicated approximately normal distribution, with minor deviations including slight positive skewness and kurtosis. The model was significant, $F(1,80) = 48.427$, $p < .001$, demonstrating that negative ES significantly predict GFD adherence. The regression model exhibited a large effect size ($R^2 = 0.37$), indicating that 37.7% of the variance in GFD adherence is explained by negative ES. The regression equation ($CDAT = 6.79 + 0.18 * DASS-21$) suggests that each one-point increase in negative ES corresponds to a 0.18-point increase in poorer GFD adherence scores. Thus, higher levels of negative ES are robust predictors of lower GFD adherence.

Table 7: Regression Analysis Summary for Negative Emotional States (DASS) on Gluten-Free Dietary Adherence (CDAT)

Variable	B	95% CI	β	t	p
(Constant)	6.790	[4.488, 9.092]		5.869	<.001
DASS Score	.176	[-.126, .227]	.614	6.959	<.001

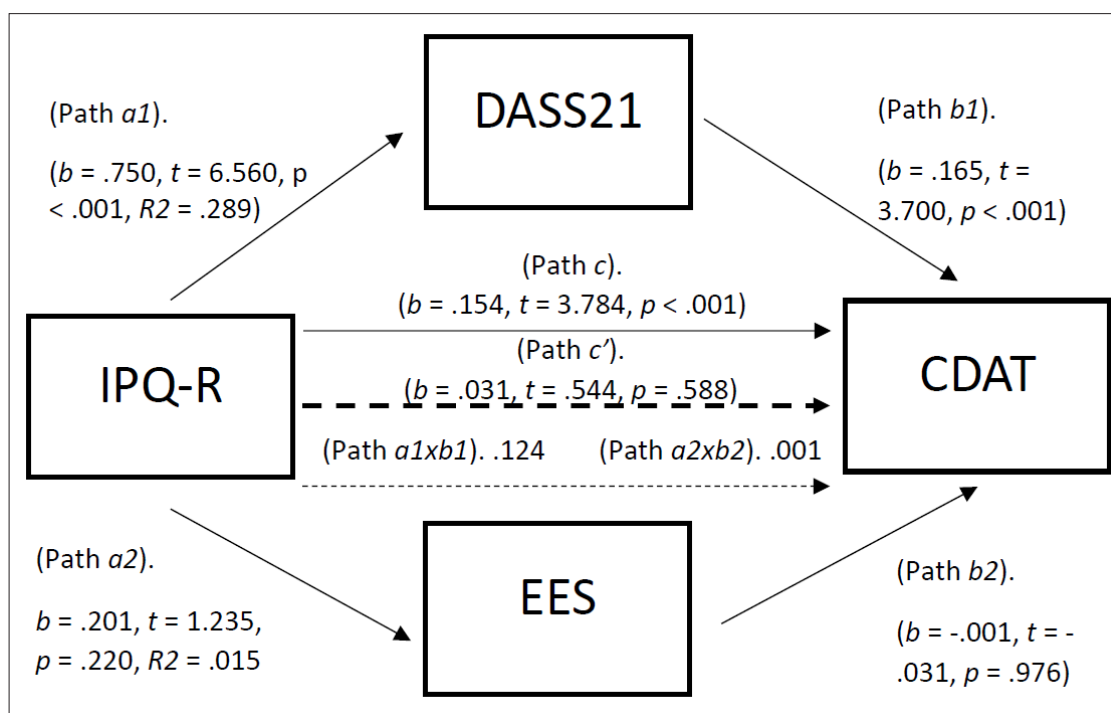
Note: R² adjusted = 0.37. CI = Confidence Interval for B.

A subsequent multiple linear regression analysis using the enter method was conducted to evaluate the extent to which CDAT is predicted by DASS-21 and its subscales [Table 8]. Assumptions for multiple regression were met. Variance Inflation Factor (VIF) values were examined to assess multicollinearity: depression (VIF= 1.79), anxiety (VIF= 2.71), and stress (VIF= 3.06), indicating no significant multicollinearity. The Durbin-Watson statistic approached 2, suggesting no autocorrelation. Inspection of residuals through scatterplots and normal probability plots confirmed normality, linearity, and homoscedasticity, demonstrating that regression assumptions were satisfactorily met. The overall model was highly significant, $F(3, 78) = 18.385$, $p < .001$, indicating that the combined predictors significantly explained the variance in CDAT scores. The model accounted for a substantial proportion of the variance in CDAT, $R^2 = 0.414$, indicating that DASS-21 subscales explained approximately 41.4% of the variance in CDAT scores. When examined individually, depression ($t = 4.128$, $p < .001$) exhibited a statistically significant positive relationship with poorer dietary adherence, whereas anxiety ($t = 0.129$, $p = .898$) and stress ($t = 1.343$, $p = .183$) did not reach statistical significance. The regression equation for predicting CDAT scores was: $CDAT = 6.921 + 0.355 (\text{depression}) + 0.016 (\text{anxiety}) + 0.151 (\text{stress})$. Standardised coefficients indicated that depression had the strongest positive impact on poorer CDAT scores ($\beta = .355$), followed by stress ($\beta = .151$), while anxiety had a negligible effect ($\beta = .016$). These findings suggest that depression significantly predicts lower GFD adherence, whereas anxiety and stress do not.

Table 8: Regression Analysis Summary for Negative Emotional States (DASS) and its Subscales (Depression, Anxiety, Stress) on Gluten-Free Dietary Adherence (CDAT)

Variable	B	95% CI	β	t	p
(Constant)	6.790	[4.488, 9.092]		6.067	<.001
Depression	.176	[-.126, .227]	.614	6.959	<.001
Score	.335	[-.174, .497]	.479	4.128	<.001
Anxiety Score	.016	[-.229, .261]	.018	.129	.898
Stress Score	.151	[-.073, .375]	.204	1.343	.183

Note: R² adjusted = 0.392. CI = Confidence Interval for B.

**Figure 1: Standardised beta weights for the mediation pathways between emotional perceptions of coeliac disease and gluten-free diet adherence through emotional eating and emotional states.**

Note. Total effect (Path c), $b = .154$, $t = 3.784$, $p < .001$; Direct effect (Path c'), $b = .031$, $t = .544$, $p = .588$; Combined Indirect effect, $b = .123$ 95% BCa CI [.066, .183]; Indirect effect on DASS21 = $b = .124$ 95% BCa CI [.066, .184]; Indirect effect on EES = $b = .001$

95% BCa CI [-.015, .012]

Mediation Analysis

A mediation analysis with a cross-sectional design was conducted to test the second hypothesis that negative ES and EE mediate the relationship between emotional perceptions of CD and GFD adherence. The results of the mediation model [Figure 1] revealed a significant indirect effect of emotional perceptions on GFD adherence through both EE and negative ES ($b = .123$, 95% BCa CI [.066,.183]). As emotional representations were identified as a significant predictor of GFD adherence when including these mediators, the combined factors were indicative of mediation. When examining EE and negative ES as mediators of the relationship between emotional perceptions and GFD adherence in isolation, it was found that negative ES significantly predicted poorer GFD adherence in a positive manner ($b = .165$, $t = 3.700$, $p < .001$), indicative of mediation, with a significant indirect effect observed ($b = .124$, 95% BCa CI [.066,.184]). In contrast, EE did not show a significant relationship with adherence ($b = -.001$, $t = -.031$, $p = .976$), and the indirect effect was non-significant ($b = .001$, 95% BCa CI [-.015,.012]), suggesting EE is not indicative of mediation.

To summarise the model, as emotional representations of CD become more negative, GFD adherence declines, as an indirect function of increased negative ES, and a direct function of negative emotional representations. Specifically, negative ES partially mediated the relationship between emotional representations of CD and GFD adherence, whereas EE did not. These findings suggest that the indirect effect observed may be attributable to the combined influence of negative ES and EE, rather than in isolation.

Moderation Analysis

Following the results of the previous tests, the moderating effects of emotional regulation strategies on the relationship between emotional perceptions of CD and negative ES were explored. An initial Pearson's correlation was computed to confirm the association between negative ES and emotional representations of CD. There was a significant, moderate to strong positive correlation between DASS-21 and IPQ-R ($r(80) = .538$, $p < .001$, two-tailed), indicating that higher levels of negative ES corresponded with higher emotional representations of CD, meeting the assumption for conducting a moderation analysis.

An initial moderation analysis set negative ES as the outcome variable, emotional representations as the predictor variable, and emotional regulation as the moderating variable [Table 9]. The mean-centred interaction term for emotional regulation significantly predicted additional variance in DASS-21 ($\Delta R^2 = .0424$, $\Delta F(1,78) = 4.6737$, $p = .0337$), indicating that emotional regulation moderated the effect of emotional representations on negative ES ($b = .0343$, 95% CI [.0027, .0659], $t = 2.1619$, $p = .0337$).

Table 9: Linear Predictors of Negative Emotional States with Emotional Representations and Emotional Regulation as a moderator

	b	SE B	t	p
Constant	42.9110	1.3482	31.8287	<.001

	[40.2270,			
	45.5951]			
Emotional	-.1850	.1893	-.9773	.3314
Regulation	[-.5620,			
	.1919]			
Emotional	.7890	.1178	6.6954	<.001
Representations	[.5544,			
	1.0236]			
Emotional	.0343	.0159	2.1619	.0337
Regulation x				
Emotional	[.0027,			
	.0659]			
Representations				

Note: 95% bias-corrected confidence intervals (CIs) are reported in brackets. CIs and Standard Errors (SEs) are based on 1000 bootstrapped samples. $R^2 = .344$.

Subsequent moderation analyses assessed the moderating effects of each subscale of emotional regulation: reappraisal and suppression. The first analysis set negative ES as the outcome variable, emotional representations as the predictor variable and cognitive reappraisal as the moderating variable [Table 10]. The mean-centred interaction term for reappraisal did not significantly predict additional variance in DASS-21 ($\Delta R^2 = .0076$, $\Delta F(1,78) = 1.0073$, $p = .3187$) indicating that reappraisal did not moderate the effect of emotional representations on negative ES ($b = .0191$, 95% CI [-.0188,.0578], $t = 1.0063$, $p = .3187$).

Table 10: Linear Predictors of Negative Emotional States with Representations and Cognitive Reappraisal as a Moderator

	b	SE B	t	p
Constant	43.4735	1.4460	30.0648	<.001
	[40.5948,			
	46.3523]			
Reappraisal	-.4268	.2294	-1.8602	.0666
	[-.8836,.0300]			
Emotional	.7441	.1230	6.0502	<.001
Representations	[.4993, .9890]			
Reappraisal x	.0191	.0190	1.0036	.3187
Emotional				
Representations	[-.0188, .0578]			

Note: 95% bias-corrected confidence intervals (CIs) are reported in brackets. CIs and Standard Errors (SEs) are based on 1000 bootstrapped samples. $R^2 = .3324$.

A subsequent moderation analysis set negative ES as the outcome variable, emotional representations as the predictor variable and suppression as the moderating variable [Table 11]. The mean-centred interaction term for suppression was marginally non-significant in predicting additional variance in negative ES ($\Delta R^2 = .0399$, $\Delta F(1,78) = 1.132$, $p = .0786$), indicating that suppression did not moderate the effect of emotional representations on DASS-21 ($b = .0474$, 95% CI [-.0055,.1003], $t = 1.7825$, $p = .0786$).

Table 11: Linear Predictors of Negative Emotional States with Emotional Representations and Expressive Suppression as a Moderator

	b	SE B	t	p
Constant	42.3426	1.4696	28.8115	<.001
	[39.4168,			
	45.2685]			
Suppression	.0375 [-.5301,	.2851	.1315	.8957
	.6501]			
Emotional	.6971	.1457	4.7840	<.001
Representations	[.4070, .9873]			
Suppression x	.0191	.0266	1.7825	.0786
Emotional				
Representations	[-.0055, .1003]			

Note: 95% bias-corrected confidence intervals (CIs) are reported in brackets. CIs and Standard Errors (SEs) are based on 1000 bootstrapped samples. $R^2 = .3329$.

The moderation analysis indicated that neither reappraisal nor suppression individually moderated the relationship between emotional representations of CD and negative ES. However, the combined effect of emotional regulation strategies showed a significant moderating effect. Specifically, the interaction terms for reappraisal and suppression did not explain additional variance in negative ES, suggesting that these strategies alone do not mitigate the impact of emotional representations. Since neither reappraisal nor suppression individually moderated the relationship significantly, no follow-up tests were conducted.

Discussion

This study explored the interrelationships and predictive roles of emotional factors on GFD adherence in CD, addressing all three research questions. It was the first to examine the mediating roles of negative ES and EE and the moderating roles of emotion regulation strategies in an international CD sample.

Predictors of GFD Adherence

The first hypothesis, which posited that variations in GFD adherence could be predicted by EE and negative ES, particularly depression and anxiety, was conditionally supported. Combined negative ES and the depression subscale emerged as significant predictors of GFD adherence, underscoring depression's prominent role in adherence, which aligns with existing CD literature [50,17]. However, anxiety and stress were not significant predictors, diverging from previous research (Ford et al.; Kerswell & Strodl). Additionally, EE did not correlate with GFD adherence, leading to its exclusion from predictive analyses, challenging theories suggesting its significance (Arigo et al., 2012). These discrepancies may stem from specific characteristics of the study sample. Future research should explore subgroups of CD populations with higher levels of anxiety, stress, and EE tendencies to better understand their potential roles in predicting GFD adherence.

Recognising that EE, stress, and anxiety may not significantly impact GFD adherence in this study shifts the focus of future interventions towards managing depression to maintain a GFD. At a healthcare system level, it may be necessary to reconsider

referral services for individuals with CD upon diagnosis. While nutritionists are commonly recommended for GFD education, guidelines suggest that counselling should coincide with nutrition to assist with emotional adjustment, specifically depression [58]. Implementing this integrated approach could improve patient outcomes by addressing both emotional and practical challenges more effectively.

Mediating Effect of Emotional Factors

The second hypothesis anticipated that negative ES and EE would mediate the relationship between emotional perceptions of CD and GFD adherence. The hypothesis was conditionally supported: worsening emotional perceptions of CD led to decreased adherence, mediated significantly by negative ES but not by EE. This suggests negative ES in CD stems from emotional perceptions of the condition, aligning with established theories and is consistent with Kerswell and Strodl's findings [50,5]. This deepens the understanding of the emotional dynamics influencing GFD adherence by highlighting the mediating role of negative ES and further underscoring the potential for interventions targeting emotional adjustment to improve GFD adherence in CD [58].

EE did not emerge as a significant mediator in this study, consistent with findings from Kerswell and Strodl [5]. The limited role of EE in these studies may be attributed to the EE scale used, which might not capture behaviours specific to GFD non-adherence.

Developing a more refined scale could enhance understanding of the relationship between emotional perceptions of CD and GFD adherence and guide future interventions. However, exploring EE's mediating effect in social contexts remains promising, as individuals with CD may deviate from their GFD to fit in socially, a behaviour resembling EE but driven by emotional perceptions and social pressures [4]. Understanding EE behaviours in these contexts could ascertain its mediating role and inform targeted interventions addressing negative CD-related perceptions to enhance adherence.

Moderating Effect of Emotion Regulation

It was anticipated that the relationship between emotional perceptions of CD and negative ES would be moderated by emotion regulation strategies, with higher levels of reappraisal buffering the impact. The hypothesis was conditionally supported; the combined effect of emotion regulation significantly moderated this relationship, but neither reappraisal nor suppression individually showed a moderating effect. Persistent negative ES in CD may indicate a need for improved management of dietary challenges [28]. These findings suggest that psychological interventions focusing solely on reappraisal or suppression may not effectively manage the emotional impact of CD. This approach contrasts with previous theories suggesting the significance of reappraisal and suppression strategies on emotional experiences [47]. However, the marginal non-significance of the suppression effect when considered individually ($p = .079$) may indicate an underpowered analysis, suggesting that the combined significant effect might be attributed to suppression. Future research should aim for adequately powered analyses to investigate this further and clarify specific mechanisms that moderate the relationship between emotional

perceptions and negative ES, thereby informing interventions that provide emotional support for individuals with CD [28].

Limitations of the Study

The study's limitations stem primarily from sample characteristics and its correlational design. It focused exclusively on members of CD groups known for higher GFD adherence [59]. This possibly excluded those with poorer adherence, as a small proportion of participants (25.6%) exhibited fair-to-poor adherence. Moreover, there was a significant overrepresentation of females (79.3%), potentially presenting gender bias. While women with CD often report lower QOL compared to men, gender disparities in dietary adherence remain underexplored [49]. Future research should employ targeted recruitment strategies, collaborating with healthcare providers and relevant organisations to include recently diagnosed CD patients with higher rates of non-adherence and achieve a more balanced gender distribution [59]. Although resource-intensive, these strategies could enhance sample inclusivity and validity of the conclusion drawn, facilitating the development of more tailored treatment strategies for a broader population of individuals with CD.

The lack of measurement for CD symptom severity may have introduced a confounding variable. Asymptomatic individuals tend to exhibit poorer GFD adherence and improved QOL compared to symptomatic CD cases [60,61]. This is possibly due to the perceived lower immediate consequences of gluten ingestion [60]. Given the variability of emotional factors and GFD adherence, the conclusions drawn may have been influenced by symptom severity that was not assessed. Currently, a specific scale designed to differentiate between asymptomatic and symptomatic CD does not exist, highlighting the need for future research to develop such a tool. Introducing a comprehensive measure to capture symptom severity in future studies could provide a more nuanced understanding of these dynamics. This advancement in CD research would help identify the unique needs of different symptom severity groups, in turn, facilitating targeted interventions to improve GFD adherence and overall well-being.

Establishing causality in GFD adherence research remains challenging [5]. While this study provides insights into the emotional aspects of CD, its correlational design limits definitive causal conclusions. The bidirectional influence between psychological factors and gastrointestinal symptoms suggests complex interactions; for instance, depression may shape illness perceptions rather than the illness directly causing depression. Future research employing structural equation modelling could clarify these relationships, deepening our understanding of how psychological factors interact with GFD adherence in CD to inform targeted interventions.

Conclusion

Adhering to a GFD is crucial for CD individuals, yet focusing solely on treatment overlooks their daily emotional challenges [22]. This study reveals that negative emotional perceptions of CD are associated with depression, which in turn relates to poorer GFD adherence. While this study found that combined emotion regulation strategies moderate this relationship, neither reappraisal nor suppression alone showed significant

effects. Further research should explore specific emotional regulation mechanisms that moderate the relationship between emotional perceptions of CD and negative emotional states, offering insights for future interventions. Future psychological interventions should target depressive symptoms and negative emotional perceptions to enhance GFD adherence. It may be necessary to reconsider CD referral practices to integrate emotional adjustment counselling with nutritional education to optimise health outcomes, enhance GFD adherence, and improve QOL in CD populations [58,62-66].

Data availability statement: Research data are not shared.

Acknowledgements

My journey through this research would not have been possible without the incredible support of my supervisors, Dr Amy Baraniak and Paul Staples. Their guidance and encouragement were invaluable, helping me navigate and overcome the inevitable hurdles of research. Special thanks are extended to the exceptional team at the University of Derby for their expertise and encouragement.

Personally, this research holds a deep significance for me as a person living with coeliac disease. The personal challenges of navigating a gluten-free lifestyle have inspired me to understand the emotional experience of this condition. Countless late nights of research, fuelled by gluten-free indulgences, were a testament to my dedication to this project.

Finally, I cannot thank my wonderful family and friends enough for their unwavering support from the beginning of my degree to the moment I clicked submit on my final project.

Statement of Contribution

What is already Known on this Subject?

- Previous research links negative emotional states to poorer GFD adherence in CD.
- Few studies suggest depression mediates the link between emotional representations of CD and GFD adherence, with only one Australian study indicating potential moderation by emotion regulation, underscoring the need for broader research.

What does this Study Add?

- Confirms higher depression levels predict lower GFD adherence.
- First to examine mediating roles of negative emotional states and emotional eating, and moderating roles of emotion regulation in an international CD sample.
- Offers insights for psychological interventions to improve adherence and well-being among CD populations.

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