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Exploring the relations between body dissatisfaction, rumination, physical activity, and restrained eating: a latent moderated structural equation approach



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Abstract

Background Previous studies have shown that body dissatisfaction is closely related to restrained eating, however, the specific mechanisms and conditions of body dissatisfaction need to be further explored. Therefore, this study aims to explore the mediating and moderating variables influencing the relations between body dissatisfaction and restrained eating, providing recommendations for the prevention of restrained eating among university students.

Methods Participants comprised 1213 university students who completed the Negative Physical Self Scale, Ruminative Responses Scale, Restrained Eating Scale, and Physical Activity Scale. Data regarding their body measurements were also obtained. A Latent Moderated Structural Equation Approach was constructed to examine the mediating role of rumination and the moderating role of physical activity in the relations between body dissatisfaction and restrained eating.

Results Body dissatisfaction was positively correlated with rumination (r = 0.19, p < 0.01), restrained eating was positively correlated with body dissatisfaction (r = 0.45, p < 0.01), and restrained eating was positively correlated with rumination (r = 0.25, p < 0.01). Path analysis of the mediation model and moderated mediation model using structural equation modeling showed that rumination explained 6.5% of the total relations between body dissatisfaction and restrained eating. Physical activity moderated the effect of body dissatisfaction on rumination.

Conclusions It suggests that as physical activity increased, the relations between body dissatisfaction and rumination were strengthened. Therefore, it is advisable for university students to avoid placing excessive emphasis on using physical activity and restrictive eating to lose weight. Instead, efforts should focus on developing healthy exercise motivations and guiding adolescents toward positive self-perception.

Plain English summary

Body dissatisfaction is common among university students, and many with such concerns turn to restrained eating to control their weight. However, there is no evidence that restrained eating effectively or sustainably reduces weight. Understanding how body dissatisfaction influences restrained eating, and under what conditions this relationship changes is critical. It can provide a theoretical basis for preventing irrational weight loss among university students. We surveyed 1,213 university students and found that rumination accounted for a significant portion of the relations

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between body dissatisfaction and restrained eating. When students had low levels of physical activity, the link between body dissatisfaction and rumination was weak. However, as physical activity increased, this connection

became stronger. Therefore, it is recommended that university students strive to cultivate a healthy and balanced approach to physical activity and develop a positive body image to reduce rumination.

Keywords Body dissatisfaction, Moderated mediation, Physical activity, Restrained eating, Rumination

Introduction

Restrained eating refers to the chronic behavior of consistently restricting food intake to control weight, requires cognitive restraint against the body's inclination to consume high-calorie foods, and is an important manifestation of eating disorders [1]. Restrained eaters often make long-term efforts to achieve or maintain an image that aligns with the societal ideals of thinness [2]. This process generally involves excessive concern with body weight, negative body image, disordered eating attitudes, restrained eating behaviors, and, ultimately, the clinical symptoms of eating disorders [3]. Conceptually, this should be distinguished from dieting, which tends to involve short-term dietary restrictions (such as losing 5 kg within a short time) and may occur at any stage of an eating disorder [4]. Owing to its complexity and contradictions, restrained eating has received significant attention from numerous researchers in recent years [5-7]. Although restrained eating is meant to control weight, there is no evidence to support the idea that restrictive eating results in effective and sustainable weight loss, and whether it effectively controls weight remains controversial. Research has suggested that although it may be effective in the short term, it often has a poor longterm success rate [8]. A seven-year longitudinal study found that restrained eating did not predict changes in body mass index (BMI) [9]. Another two-year longitudinal study also found that restrained eating was not associated with weight change [10]. The literature indicated that any negative effects of restrained eating are mediated by a disinhibition effect [11-13]. In some cases, this disinhibitory effect develops into a full-blown eating disorder [12]. In general, if an individual's weight is within a natural range of fluctuations, and when the individual consciously reduces weight by restrained food intake, the balance between hunger and satiety breaks down over time. Persistent hunger, decreased metabolic rate, changes in the perceptions of eating, and reverse regulation also occur [14]. Therefore, restrained eating may tend to lead to long-term weight gain in the long run. This exacerbates issues such as obesity, binge eating, nutritional imbalances, anxiety, and depression, thereby increasing the global public health burden [15]. Researchers worldwide have strongly suggest that college students should not engage in restrained eating to lose weight [16]. However, with increased focus on weight loss and fitness and the concept of "thin is beautiful" promoted by social platforms, an increasing number of college students are beginning to follow restrained eating. A survey of Chinese college students found that 35% attempted to lose weight through dietary control [17]. In addition, a meta-analysis of 89 studies with 145,629 participants from 40 countries indicated that 19.7% of undergraduate university students exhibited screen-based disordered eating [18]. Cross-sectional surveys conducted every three years among French university students showed that during the COVID-19 pandemic, the prevalence of eating disorders significantly increased, with the prevalence among females and males rising by 20% and 18%, respectively [19]. Moreover, many college students are affected by undiagnosed and potentially untreated eating disorders, and research on restrained eating among Chinese university students remains limited [20]. College students are exposed to diverse dietary environments and a wide range of food choices, leading to changes in eating behaviors and the gradual formation of food preferences. However, without proper dietary guidance, these individuals are prone to developing unhealthy eating habits.

Body dissatisfaction and restrained eating

healthy development in university students.

Body dissatisfaction is the most reliable predictor of restrained eating [21] Body dissatisfaction can be defined as a negative attitude towards one's body resulting from a perceived discrepancy between the actual and ideal body image [22]. Restrained eaters consistently expressed dissatisfaction with themselves and endorsed a thin ideal body size and shape to a much greater extent than unrestrained eaters [5]. It is important to note that the psychological phenomenon of body dissatisfaction is spreading worldwide, and its prevalence is increasing,

Therefore, restrained eating is an early behavior of eat-

ing disorders, investigating how restrained eating develops and intensifies in university students and under what

conditions the strength of this effect change is important.

We must also understand the motivation and mechanism of university students' restrained eating and to

clarify the internal mechanisms leading to an increased risk of restrained eating, providing scientific evidence to

promote the reduction of restrained eating and support

becoming a public health problem [23]. Individuals who experience stress and anxiety owing to body dissatisfaction often resort to restrained eating as an immediate coping mechanism [24]. A prospective cohort study of Mexican university students showed a prevalence of body dissatisfaction ranging from 65.3 to 71.7%, with eating disorder behaviors ranging from 25 to 38.3%, and body dissatisfaction being strongly associated with eating disorders [25]. It is worth noting that while body dissatisfaction may precede restrained eating, recent research has found a bidirectional relations between body dissatisfaction and restrictive eating. In other words, body dissatisfaction can lead to restrained eating, which can further exacerbate body dissatisfaction, creating a cyclical pattern [26]. In addition, cognitive and affective characteristics have been identified in individuals with restrained eating, suggesting a correlation between restrained eating and these characteristics [27]. Cognitive control is an important factor affecting restrained eating. When faced with food, individuals must engage in cognitive control to balance the conflict between dietary goals and food temptations. Cognitive models of body dissatisfaction describe multiple processes involved in the development and maintenance of body image issues [28], one of which is the ruminative thinking style [29].

The relations between body dissatisfaction, rumination and restrained eating

Emotional or cognitive response patterns can result in persistent characteristics. Rumination plays a crucial role in body dissatisfaction and restrained eating. A recent cross-sectional study on eating behaviors among adults in Lebanon found a significant positive correlation between rumination and restrained eating, and it was hypothesized that rumination exacerbates the restriction of food intake through repetitive thinking about eating behaviors [30]. The findings of another study involving 119 female university students in Australia emphasized the association between rumination and restrained eating [31]. Additionally, research using an exogenous cueing task indicated that restrained eaters are more sensitive to food cues; when faced with food temptations, they must exert more cognitive effort to suppress impulsive eating and engage in more cognitive resources to balance the conflict between dietary goals and food temptations [32]. This aligns with the idea that rumination, as a repetitive and passive thinking process, may contribute to the increased cognitive effort observed in restrained eaters [33]. Rumination is a common negative cognitive response characterized by a constant focus on one's uncontrollable negative state and involves repetitive passive thinking about something [34]. Some researchers consider rumination to be a psychological habit in the face of negative emotions [35]. The underlying logic of why rumination occurs can be explained by the responsegoal-driven theory. This theory posits that rumination arises as a cognitive self-management process when ideal goals are unachievable. Therefore, when goal-related information relate arises, individuals prone to rumination show heightened sensitivity, leading them to repeatedly think about ways to achieve these goals [36]. University students, in particular, are at high risk of body dissatisfaction [37]. If this negative attitude persists, it will prompt them to adopt coping strategies, with restrained eating being the most direct response. A study of 780 ethnically diverse undergraduate students found that the interaction between body dissatisfaction and rumination was a significant predictor of eating disorders [38]. Additionally, a meta-analysis of rumination and eating disorders showed that rumination is a significant process in the psychopathology of eating disorders [35]. This indicates that rumination is closely related to both body dissatisfaction and restrained eating, rumination may mediate the relations between body dissatisfaction and restrained eating.

The moderating effect of physical activity

The mediating effect can address the specific pathway through which body dissatisfaction affects restrained eating, but it primarily focuses on the "commonality" of the variable relations. It cannot explain the conditions under which body dissatisfaction more significant impact restrained eating—the "individuality" of the effect. Additionally, most previous research supports the hypothesis of negative emotion as a mediator, but variations in effect sizes suggest that the relations between body dissatisfaction and restrained eating may be moderated by other factors [39]. Therefore, this study also examined the moderating effect of physical activity, an important variable affecting the physical and mental health of university students, on the mediating pathway of "body dissatisfaction \rightarrow rumination \rightarrow restrained eating".

Although previous empirical studies have shown that individuals with body dissatisfaction tend to use physical activity as methods to control their weight [40], few studies have considered physical activity as a moderating variable affecting association between body dissatisfaction and rumination. However, this hidden pathway may indeed exist. Physical activity is closely related to cognitive [41]. Experimental studies have found that short-term physical activity is associated with a higher degree of rumination compared to a resting state. This may be because physical activity directly affects the activity of the prefrontal cortex of the brain, a brain region related to higher cognitive functions associated with rumination [42]. In the Lebanese sample, a significant

correlation was found between higher physical activity index, restrained eating, and rumination [30] In addition, empirical studies have found a significant positive correlation between the physical activity frequency of young women and their body dissatisfaction [43] In a sample of undergraduate students who engage in physical activity regularly, it was found that physical activity to control weight and increase attractiveness is associated with negative body image [44]. Ginis found that women who are more concerned about their body image experience increased anxiety about their appearance after exercising and report higher levels of body dissatisfaction [45]. This may be because individuals with high levels of body dissatisfaction experience more negative emotions from physical activity. In a study with a community sample primarily consisting of female participants, those who engaged in high-intensity physical activity had a higher degree of dietary restraint than those who participated in moderate- or low-intensity physical activity [46]. Franco et al. found that weightlifters and bodybuilders are subpopulations at an increased risk of eating disorders [47]. These findings suggest that physical activity may moderate the relationship between body dissatisfaction and rumination. Specifically, as the level of physical activity increases, the association between body dissatisfaction and rumination becomes stronger, thereby indirectly influencing restrained. However, research on the moderating role of physical activity on the relations between body dissatisfaction and rumination is limited. There is a lack of research on university students in southern China. To better understand the complex ways in which body dissatisfaction affects restrained eating, this study proposes the following hypotheses based on the ideal model (Fig. 1):

- (1) Body dissatisfaction is positively associated with restrained eating.
- (2) Body dissatisfaction is positively associated with rumination.
- (3) Rumination explains a significant portion of the relations between body dissatisfaction and restrained eating.
- (4) Physical activity level is positively correlated with rumination and body dissatisfaction.
- (5) The relations between body dissatisfaction and rumination are influenced by physical activity. The level of physical activity moderated the first half of the pathway from dissatisfaction to rumination to restrained eating. Specifically, the higher the physical activity level, the stronger the relations between body dissatisfaction and rumination.

Method

Participants

This study was approved by the Ethics Committee of Gannan Medical University (No. 2021110). All procedures were conducted in accordance with the ethical standards of the Institutional Research Committee and the Declaration of Helsinki. Convenience sampling was used to survey students from two large universities in Jiangxi Province. We recruited participants by posting advertisements in student dormitories and study rooms and conducted body measurements and questionnaires



Fig. 1 Conceptual model of the study

during evening self-study hours. All investigators underwent standardized training and informed the participants about the content and purpose of the study before the survey. The participants provided signed informed consent forms that allowed them to withdraw from the study at any time. The inclusion criteria were as follows: (1) participants must be enrolled as university students; (2) those between 18 and 24 years old; (3) voluntary participation with signed informed consent; and (4) no serious physical illnesses. The exclusion criteria were as follows: (1) participants who did not sign the informed consent form; (2) missing demographic data; (3) inconsistent responses to the questionnaire, such as selecting the same answer for multiple items or showing patterns that indicated a lack of engagement with the questions; (4) younger than 18 or older than 24 years old; and (5) presence of serious physical illnesses. A total of 1,213 questionnaires were included in the final analysis. Among the participants, 196 men and 1,017 women. The average age of the participants was 19.1±1.0. All participants completed the relevant measurements and questionnaires. The survey was conducted between November 2023 and April 2024.

Demographic information

Data regarding the participants' sex and age were collected using a standardized questionnaire. Height was measured using a portable stadiometer (Seca 213, Germany) with an accuracy of 0.1 cm. Weight (with an accuracy of 0.1 kg), body fat percentage, and muscle mass (with an accuracy of 0.1 kg) were measured using a body composition analyzer (Tanita BC610, Japan). These instruments are widely used worldwide. BMI (kg/m²) was calculated using height and weight measurements. According to the Physical Fitness Measurement Standards for Chinese Students, BMI is classified as follows: underweight (male: BMI \leq 17.8; female: BMI \leq 17.1), normal (male: 17.8 < BMI < 24.0; female: 17.1 < BMI < 24.0), overweight (24.0 \leq BMI < 28.0), and obese (BMI \geq 28.0).

Body dissatisfaction

The Negative Physical Self Scale (NPSS), developed by Chen Hong (2003) has been widely used in Chinese adolescents [48]. In this study, to assess individuals' dissatisfaction with their body shape, the Negative Physical Self Scale-Fatness Subscale (NPSS-F) was selected. The NPSS-F scale consists of 11 items. Responses are rated on a 5-point scale, with 0= "never" and 4= "always." The average scores for each dimension and for the entire population were calculated. A score of 2 or higher indicates dissatisfaction with one's body shape, with higher scores reflecting stronger negative cognition and emotions related to perceived obesity. Cronbach's α coefficient of the scale is 0.88.

Rumination

The Chinese version of the Ruminative Responses Scale compiled by Nolen-Hoeksema et al. and revised by Han et al. was adopted [49]. This scale is widely used among Chinese adolescents and consists of 22 items divided into three dimensions: symptom rumination, brooding, and reflective pondering, and reflective pondering. Responses were scored on a 1–4 Likert scale, with higher total scores indicating a greater tendency toward rumination. Cronbach's α coefficient of the scale is 0.96.

Restrained eating

The Restrained Eating Scale from the Dutch Eating Behavior Questionnaire (DEBQ), compiled by Van Strien et al., is widely used with Chinese adolescents and has been shown to have good reliability and validity [50]. The scale consists of 10 items (e.g., "If you gain weight, do you eat less than usual?"). Responses are scored on a 1-5 Likert scale. A higher total score indicated a higher degree of restrained eating. Cronbach's α coefficient of the scale is 0.91.

Physical activity

The Physical Activity Rating Scale (PARS-3) was used in this study. The scale was originally compiled by Hashimoto and translated and revised by Liang et al. [51]. It assesses the level of physical activity over the past month based on three aspects: intensity, duration, and frequency of participation in physical activity. Each item is scored from 1 to 5. The total physical activity score is calculated using the formula: intensity \times (duration -1) \times frequency, with scores ranging from 0 to 100. Higher scores indicate higher levels of physical activity. The specific classification of physical activity levels is as follows: ≤ 19 points indicate low physical activity, 20-42 points indicate moderate physical activity, and \geq 43 points indicate high physical activity. This scale is widely used globally and by Chinese university students. Cronbach's a coefficient of the scale is 0.75.

Data analysis

The data were analyzed using SPSS (version 19.0; IBM Corp., Armonk, NY, USA) and Mplus (version 8.3; Muthén & Muthén, Los Angeles, CA, USA). The analytical process was divided into five steps.

 Descriptive and correlation analyses, exploratory factor analysis, and reliability analysis were conducted on the main variables of the study

- (2) Evaluation of Measurement Model. Confirmatory factor analysis (CFA) was used to assess the measurement model, which included all indicators.
- (3) Testing the mediating effects. We tested the mediating effect of rumination using a mediation analysis procedure based on structural equation modeling (SEM). The confidence intervals for each coefficient were estimated using the bias-corrected nonparametric percentile bootstrap method with 5000 bootstrap samples to calculate the bias-corrected 95% confidence interval.
- (4) Testing the Moderating Effect of Physical Activity Using Latent-Moderated Structural Equations (LMS). The LMS method was used to examine the moderating effects of physical activity. Compared to traditional regression methods, LMS can correct measurement errors when estimating latent interaction effects, provide accurate estimates of effects and confidence intervals, and yield parameter values and standard errors using maximum likelihood estimation. Additionally, LMS avoids inconsistent parameter estimates caused by constructing product indicators and does not require interaction terms to follow a normal distribution, thus eliminating the bias introduced by the nonnormal distribution of product terms. The acceptability of the moderated mediation SEM model based on the LMS was evaluated in two steps. First, we used commonly employed fit indices to evaluate the baseline SEM without latent interaction terms. These indices include the comparative fit index (CFI), Tucker-Lewis index (TLI), standardized root mean square residual (SRMR), and root mean square error of approximation (RMSEA). Next, we determined whether the moderated mediation SEM with latent interaction terms provided a better fit. As the LMS does not provide traditional fit indices, we used the Akaike Information Criterion (AIC) and log-likelihood to assess improvement. A reduction in the AIC, which represents the loss of information, indicates an improved model. Additionally, we tested the likelihood ratio (LR) using

the formula LR = -2LL (the difference in log-likelihoods between the baseline model and the moderated mediation model). The LR statistic follows an approximate chi-square distribution, with degrees of freedom equal to the difference in degrees of freedom between the baseline and moderated mediation models. A significant chi-square test of the LR indicated that including the moderated mediation model was preferable.

(5) The interaction effect was interpreted using the Johnson-Neyman technique. To explore the relations between body dissatisfaction and rumination at different levels of physical activity, we estimated significance intervals and determined the boundaries of the regions of significance.

Results

Common method deviation test

The Harman single-factor test was used for the common method deviation test and ten common factors with eigen roots greater than one were identified. The first factor explained 18.17% of the variance, which did not reach the critical standard of 40%. Therefore, no significant methodological bias was observed in the study variables.

Descriptive statistics and correlations of variables

The mean scores of body dissatisfaction, rumination, restrained eating, physical activity, and BMI were 1.36 ± 0.68 , 43.01 ± 12.18 , 25.82 ± 8.19 , 17.18 ± 14.74 , and 21.38 ± 4.10 respectively (Table 1). Body dissatisfaction positively correlated with rumination (r=0.19, p < 0.01), restrained eating positively correlated with body dissatisfaction (r=0.43, p < 0.01) and restrained eating positively correlated with rumination (r=0.25, p < 0.01). Hypothesis 1 and Hypothesis 2 were supported. Physical activity positively correlated with restrained eating (r=0.07, p < 0.05). However, no significant correlation was found between BMI and the other variables. Therefore, the BMI was excluded from the moderated mediation model.

Table 1
Descriptive statistics and correlations of the variables (n = 1213)
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Variable	М	SD	1	2	3	4	5
1 Body dissatisfaction	1.36	0.68	1				
2 Rumination	43.01	12.18	0.19**	1			
3 Restrained eating	25.82	8.19	0.43**	0.25**	1		
4 Physical activity	17.18	14.74	- 0.02	0.04	0.07*	1	
5 BMI	21.38	4.10	0.02	- 0.04	0.01	- 0.03	1

M; Mean, SD; standard deviation

*p<0.05; **p<0.01

Measurement model evaluation

Our study included four latent variables: body dissatisfaction (11 indicators), rumination (22 indicators), physical activity (three indicators), and restrained eating (10 indicators). The results of a confirmatory factor analysis indicated that the measurement model had a good fit: χ^2 =5345.86, df=983, CFI=0.91, TLI=0.90, SRMR=0.05, and RMSEA=0.06, with a 90% confidence interval for RMSEA of [0.059, 0.062]. Detailed information on the standardized factor loadings for each indicator corresponding to the latent variables can be found in the Supplementary Table.

Testing the mediating role of rumination

We examined the role of rumination in the relations between body dissatisfaction and restrained eating using structural equation modeling, with confidence intervals for each coefficient estimated using the bias-corrected nonparametric percentile bootstrap method. The results indicated that the model fit the data well: $\chi^2 = 5411.09$, df = 986, CFI = 0.90, TLI = 0.89, SRMR=0.05, and RMSEA=0.06, with a 90% confidence interval for RMSEA of [0.059, 0.062]. The path analysis, as shown in Table 2, revealed significant relations among the variables: the paths from body dissatisfaction to rumination ($\beta = 0.118$, p < 0.001), from rumination to restrained eating ($\beta = 0.295$, p < 0.001), and from body dissatisfaction to restrained eating were significant ($\beta = 0.496$, p < 0.001). The estimated indirect effect was 0.035 (p < 0.001, 95% CI [0.020, 0.050]), indicating that rumination explained 6.5% of the total relations between body dissatisfaction and restrained eating. Hypothesis 3 was supported.

Testing the moderating effect of physical activity on the mediating effect

We tested the moderating effect of physical activity using the LMS method, which is divided into three steps. First, we evaluated the baseline SEM model, which included physical activity as a moderating variable but excluded the interaction terms (removing XW and a_3 from Fig. 2). The results indicated good model fit: $\chi^2 = 5408.79$, df=985, CFI=0.90, TLI=0.89, SRMR=0.05, Loglikelihood H0=-59,347.93, AIC=118,979.854, and RMSEA = 0.06, with a 90% confidence interval of [0.059, 0.062]. Next, we evaluated the moderated mediation SEM model, which included an interaction term. The fit indices for this model were AIC=118,977.86, Loglikelihood H0=- 59,345.93, LR=3.99, and Δ df=1, and the chi-square test was significant (p < 0.05), indicating that the moderated mediation SEM model showed a significantly better fit compared to the baseline SEM model. As shown in Fig. 2 and Table 2, the main effect of physical activity on rumination was not significant ($\beta = 0.02$, 95%CI [-0.006,0.048]). However, the interaction term between body dissatisfaction and physical activity was significant, indicating the presence of a moderating effect $(\beta = 0.04, 95\% CI [0.001, 0.007], p < 0.05)$. Finally, interpret the moderating effect. The interaction plot based on the Johnson-Neyman technique is presented in Fig. 3. The horizontal axis represents the values of physical activity, and the vertical axis represents the moderated indirect effect. When physical activity is higher than -1.6, the 95% confidence interval no longer includes 0, indicating that the effect of body dissatisfaction on rumination became significant. As s physical activity increased, the relations between body dissatisfaction and rumination was strengthened. Hypothesis 5 was supported.

Table 2 Path analysis of the mediation model and moderated mediation model using structural equation modeling

	Effect	S. E	t	p	95%BCLL	95%BCUL
Mediation model						
Body dissatisfaction on Rumination	0.118	0.018	6.485	< 0.001	0.082	0.153
Rumination on restrained eating	0.295	0.052	5.708	< 0.001	0.193	0.396
Body dissatisfaction on Restrained eating	0.496	0.036	13.913	< 0.001	0.426	0.566
Indirect effect	0.035	0.008	4.513	< 0.001	0.020	0.050
Total effect	0.531	0.036	14.697	< 0.001	0.460	0.602
Moderated mediation model						
Body dissatisfaction on Rumination	0.118	0.018	6.520	< 0.001	0.083	0.154
Physical activity on rumination	0.021	0.014	1.524	0.127	-0.006	0.048
Body dissatisfaction*Physical activity on rumination	0.035	0.018	1.982	< 0.05	0.001	0.007
Rumination on restrained eating	0.295	0.052	5.717	< 0.001	0.194	0.397
Body dissatisfaction on Restrained eating	0.495	0.036	13.890	< 0.001	0.425	0.565

SE; standard error, 95% BCLL; bias-corrected confidence interval lower limit derived from bootstrap estimates, 95% BCUL; bias-corrected confidence interval upper limit derived from bootstrap estimates



Fig. 2 Moderated mediation structural equation model path diagram. *Note* For simplicity, the observed indicators of the latent variables are not fully displayed. *p < 0.05, ***p < 0.001

Discussion

This study found that body dissatisfaction and rumination were positively associated with restrained eating. Rumination accounted for a significant portion of the relations between body dissatisfaction and restrained eating, accounting for 6.5% of the total effect between body dissatisfaction and restrained eating. Additionally, when the interaction term was included, the moderated mediation SEM showed a significantly better fit than the baseline SEM. The interaction between dissatisfaction and physical activity was significant, indicating a moderating effect. As physical activity increased, the relations between dissatisfaction and rumination strengthened.

The results of this study indicate that body dissatisfaction is significantly and positively correlated with restrained eating. In previous studies examining the relations between body dissatisfaction and restrained eating through cross-sectional or longitudinal analyses, body dissatisfaction has consistently been shown to be a significant predictor of restrained eating [6]. The results of our study support those of previous studies. People with body dissatisfaction engage in restrained eating behaviors to control their weight. This highlights the essential role of body dissatisfaction and suggests the importance of reducing body dissatisfaction in the field of eating behavior.

Restrained eating may be used to alleviate body dissatisfaction. These findings are similar to those found in Western countries, suggesting that although stereotypes may exist about ideal body types in different cultures, restrained eating due to body dissatisfaction has become a global problem that remains to be solved [52]. However,



Fig. 3 Effects of body dissatisfaction on rumination with Johnson-Neyman confidence bands

the results of this study showed that BMI was not associated with body dissatisfaction or restrained eating. Previous studies have shown that BMI is positively correlated with the symptoms of body dissatisfaction and eating disorders and people with a higher BMI may face social prejudice and a greater pressure to lose weight [53]. As such, they are prone to body dissatisfaction and, thus, eating disorders [54]. The possible explanations for this discrepancy are that the participants in this study were general university students rather than clinical samples, and their BMI was mostly within the normal range.

Additionally, restrained eating behaviors are more challenging to identify in overweight individuals, and the duration of restrained eating symptoms tends to be longer in this group [54]. Indeed, this finding suggests that susceptibility to restrained eating is not limited to individuals with higher BMIs; even those with a normal BMI can experience body dissatisfaction, leading to restrained eating. For instance, individuals with perfectionistic personality traits may be excessively concerned about their appearance and are more likely to engage in restrained eating [55].

Results showed that rumination accounted for a significant portion of the relations between body dissatisfaction and restrained eating. This is consistent with previous findings and extends the research on southern Chinese adolescent populations, providing further evidence that rumination contributes to the maintenance or development of restrained eating [56].

Restrained eating is related to rumination, which can be contrasted with intuitive eating. Intuitive eaters do not ruminate about dieting or food, nor do they ignore hunger signals. Instead, intuitive eaters eat food that they enjoy, rely on hunger cues to determine how much to eat, and stop eating based on satiety signals [57]. Changing from instinctive intuitive eating to restrained eating implies shifting the physiological control of food to cognitive control, which may be driven by rumination. The response style theory suggests that individuals with a tendency to ruminate often focus excessively on selfrelated negative information [58]. Therefore, individuals with high levels of rumination exhibit maladaptive eating behaviors, restrained eating [31]. In addition, the emotional cascade model holds that negative emotions increase exponentially over time, eventually leading individuals to adopt maladaptive behaviors to disperse emotional distress [59]. Therefore, when individuals perceive a gap between the ideal and actual body, resulting in body dissatisfaction, they are likely to fall into a state of rumination. For example, they may often think "why am I so fat" and "why can't I eat less to control my weight." In such cases, restrained eating is used as a coping strategy to escape negative emotions in a negative state. Although this study could not establish causation, it provided preliminary support for the importance of rumination in a restrained eating model. These results suggest that rumination may help maintain eating disorder behaviors. However, extensive longitudinal work is needed to further support the model and explore potential causal relations.

This study found that physical activity moderates the process of "body dissatisfaction \rightarrow rumination \rightarrow restrained eating," specifically affecting the early part of the mediation chain. When physical activity scores were low, the association between body dissatisfaction and rumination was weaker, whereas as physical activity scores increased, the association between body dissatisfaction and rumination became stronger. When we consider why physical activity levels may moderate this mediation model, we must first think about the motivation for physical activity. Previous research has shown that healthy physical activity motivations can enhance self-esteem, reduce body dissatisfaction, and lessen eating pathology. However, when physical activity motivation is viewed as a compensatory behavior, exercising to compensate for or counteract body dissatisfaction is associated with negative outcomes [60]. Empirical studies have also shown that individuals who engage in physical activity to improve their appearance are more concerned about others' perceptions of their bodies than those who engage in physical activity for health reasons and are, at the same time, more prone to rumination [61]. For example, as the level of physical activity increases, expectations for the ideal body intensify. According to the response-goal-driven theory of rumination, individuals are more likely to exhibit heightened sensitivity to body shape and repeatedly contemplate ways to achieve the ideal body [36], the relations between body dissatisfaction and rumination becomes stronger. This may include checking one's body shape frequently in the mirror, repeatedly comparing photos of yourself with others on social media, thinking about whether your movement is standard, and worrying about whether you have achieved your movement goal. In addition to physical activity motivation, morbid exercise behavior may be a underlying reason for the association between physical activity, body dissatisfaction, and ruminative thinking. Morbid exercise represents a severe form of pathological exercise behavior, characterized by increasingly uncontrollable exercise habits, irrespective of the actual time spent exercising. It involves both excessive exercise and driven weight control [62]. When exercise becomes an "increasingly uncontrollable behavior", it can lead to physical and psychological harm, even if it is perceived as having the potential to change body shape [63]. The meta-analysis results regarding body dissatisfaction and morbid exercise behavior indicate a significant positive correlation [64]. When individuals engage in physical activity because of body dissatisfaction, they reflect a maladaptive cognitive process that reinforces the association between body dissatisfaction and ruminative thinking. For example, they may ruminate over missing an opportunity to exercise. Therefore, the greater the exercise intensity, the stronger the association between body dissatisfaction and ruminative thinking.

Overall, both the morbid exercise behavior and physical activity motivation were related to body dissatisfaction and may be the processes behind the association between body dissatisfaction, physical activity, and ruminative thinking. Most individuals with body dissatisfaction pursue an ideal body image that goes far beyond what can be achieved with a reasonable diet or physical activity. Although this study did not directly measure these two constructs, it has demonstrated the importance of physical activity in the context of body dissatisfaction and ruminative thinking related to restrained eating. Future

research can further explore these mechanisms to gain a

comprehensive understanding of their relations. This study verified the mediating role of rumination in the relations between body dissatisfaction and restrained eating and found that different physical activity levels moderate the relations between body dissatisfaction and rumination. This provides a detailed explanation of the complex mechanisms through which body dissatisfaction affects restrained eating, highlighting the crucial role of rumination in mediating adverse psychological and behavioral outcomes in university students, and provides important evidence regarding the role of physical activity as a moderating variable. However, this study had some limitations. First, although we employed a mediation model to explore the relations between rumination and restrained eating in the context of body dissatisfaction, we must acknowledge that we cannot confirm whether rumination indeed serves as a mediating factor preceding restrained eating. Validating mediation effects typically requires a longitudinal measurement design to ensure that changes in rumination occur prior to restrained eating. Thus, future research should utilize methods such as ecological momentary assessment to collect real-time data, allowing for a more accurate capture of the causal relations between variables. Second, this study only measured physical activity and did not directly assess physical activity motivation and morbid exercise behavior. Future research should comprehensively investigate physical activity situations, including patterns, locations, and motivations, and conduct long-term tracking of physical activity to observe whether physical activity affects rumination and restrained eating change. Third, the measures used in this study were based on the current demographics of healthy university students in southern China, which may limit the generalizability of our findings to other populations. Future studies should explore these relations using measures tailored to different demographic groups to determine whether similar patterns and associations emerge. Additionally, future research should expand the sample size to include clinical populations and individuals from different regions. Finally, owing to the imbalanced gender ratio in the sample of this study, sex differences in the model were not considered. Future sampling should ensure a more balanced gender ratio to explore the role and influence of gender in the model more comprehensively.

Conclusion

The conclusions of this study are as follows: Body dissatisfaction positively predicts restrained eating behaviors; rumination partially mediates the relations between body dissatisfaction and restrained eating, and physical activity moderates the effect of body dissatisfaction on rumination. Specifically, when physical activity levels are low, the association between body dissatisfaction and rumination is weaker. As physical activity levels increase, the association between body dissatisfaction and rumination between body dissatisfaction and r

In the context of restrained eating, physical activity might trigger more ruminative thinking. Therefore, it is advisable for university students to avoid placing excessive emphasis on using physical activity and restrained eating to lose weight. Instead, efforts should focus on developing healthy physical activity motivation and guiding university students toward positive self-perception. Future research should include diverse populations to enhance the generalizability of the findings; adopt a longitudinal study design to more accurately capture the causal relations between rumination and restrained eating; comprehensively examine physical activity, including physical activity patterns, locations, and motivations, to gain a deeper understanding of the role of physical activity in the model; and conduct longterm tracking of physical activity to observe whether physical activity influences rumination and restrained eating.

Supplementary Information

The online version contains supplementary material available at https://doi. org/10.1186/s40337-025-01229-7.

Additional file 1. Additional file 2.

Acknowledgements

We would like to express our appreciation to all the participants.

Author contributions

Y.W. conceived and designed the study, performed the data analysis, wrote the original draft, and reviewed and edited the manuscript. C.W. and Q.W. was involved in the investigation and review and editing of the manuscript. G.L was responsible for funding acquisition and review and editing of the manuscript. M.H reviewed and edited the manuscript, supervised the project, handled formal analysis, managed resources, and administered the project. All authors contributed to this study and approved the submitted version.

Funding

Humanities and Social Sciences Fund from the Ministry of Education of China (22YJC630085). Humanities and Social Sciences of Jiangxi University in 2023 (GL23114). Starting Research Fund from the Gannan Medical University (QD202121).

Availability of data and materials

The datasets used and analyzed in the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the ethics committee of Gannan Medical University, China, No. 2021110. This study was conducted in accordance with the Declaration of Helsinki and relevant guidelines and regulations. Each participant provided written informed consent in relation to the required measurement and survey completion procedures.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

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Received: 24 November 2024 Accepted: 24 February 2025 Published online: 18 March 2025

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