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ORIGINAL ARTICLE

Associations between fear of weight gain and exercise in binge-spectrum eating disorders

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Abstract

Purpose Maladaptive exercise (i.e., exercise that is either driven or compensatory) is thought to momentarily down-regulate elevated fear of weight gain (FOWG). However, little research has examined associations between FOWG and exercise, and no research has measured FOWG at a momentary level or considered exercise type (i.e., maladaptive vs. adaptive). Thus, we examined both within- and between-subject associations between FOWG and exercise among individuals with transdiagnostic binge eating.

Methods We recruited treatment-seeking adults ($N = 58$, 82.9% female) to complete a 7–14-day ecological momentary assessment protocol which assessed levels of FOWG and exercise engagement and type. Mixed models and generalized estimating equations assessed within-subject associations, and linear regression assessed between-subject associations.

Results There was no main effect of FOWG on exercise engagement at the next survey. However, unexpectedly, exercise type moderated this relationship such that the relationship between FOWG and exercise was strongest for episodes of adaptive exercise. Overall exercise frequency accounted for 10.4% of the variance in FOWG and exercise type explained an additional 1.7% of the variance in FOWG.

Conclusion The findings of the current study indicate that momentary levels of FOWG are associated with subsequent adaptive exercise episodes, while higher overall levels of maladaptive exercise were associated with higher levels of FOWG. Future treatments should place a greater emphasis on reducing the frequency of maladaptive exercise by providing strategies for reducing FOWG.

Level of evidence Level IV: Evidence obtained from multiple time series analysis such as case studies.

Keywords Binge eating disorder · Bulimia nervosa · Exercise · Fear of weight gain

Introduction

Binge-spectrum eating disorders (EDs, i.e., bulimia nervosa and binge eating disorder) affect approximately 2% of adults [1], and are characterized by a subjective sense of loss of control over eating and may include engagement in inappropriate compensatory behaviors such as purging or maladaptive exercise. For those with EDs, engagement in maladaptive exercise may be described as 'compensatory' (i.e., designed to "compensate for" calories consumed) *and/or* 'driven' (i.e., feeling compelled to exercise to avoid negative consequences associated with not exercising such as increases in negative affect) [2, 3]. Approximately 40–60% of individuals with binge eating engage in maladaptive exercise [4]; however, the proportion of episodes that are maladaptive may vary. For example, Lampe and colleagues found that 43.1% or participants with binge-spectrum EDs endorsed both maladaptive and adaptive exercise episodes during the study period, and those who reported maladaptive exercise episodes engaged in adaptive exercise 26.8% of the time on average [5]. Engagement in compensatory behaviors such as maladaptive exercise is thought to be maintained by an over-emphasis on body shape and weight in self-evaluation, which leads to increased fear of weight gain (FOWG) and its consequences (e.g., social rejection) [6, 7]. Increased FOWG may maintain maladaptive exercise by encouraging

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the use of exercise to maintain control over one's weight and/or shape [2].

Additionally, exercise may also serve to maintain FOWG. Current theories posit that positive and negative reinforcement systems maintain maladaptive exercise by decreasing negative affect and, to a lesser extent, increasing positive affect [2, 3]. Further, exercise has been theorized to help individuals with EDs regulate other cognitive-affective experiences such as body dissatisfaction. For example, one study found that in a community sample, those with higher FOWG also engaged in more frequent exercise in addition to more frequent dieting [8]. More recent work has found similar associations between FOWG and vigorous exercise in a transdiagnostic ED sample [9]. Additionally, another recent study found that FOWG mediated the relationship between over-emphasis on body shape and weight in self-evaluation and compulsive exercise frequency [10]. However, extant literature is cross-sectional in nature and has mainly used retrospective self-report measures of both FOWG and exercise over long periods (e.g., several months). Thus, the momentary relationship between exercise and FOWG is not clear. Additionally, no studies to date have examined potential bidirectional momentary, relationships between FOWG and exercise that may elucidate whether exercise engagement to down-regulate FOWG. Further, an examination of trajectories of change in FOWG pre- and post- exercise will allow us to evaluate if exercise serves to attenuate (or change in some way) FOWG in this population.

Among those who engage in maladaptive exercise, the proportion of episodes that are maladaptive may vary. For example, some exercise episodes may be maladaptive while others may be more adaptive [e.g., for perceived health benefits; 5]. Based on extant literature, it is also possible that associations between FOWG and exercise depend on the type of exercise episode (maladaptive vs. adaptive). For example, individuals may experience steeper increases in FOWG prior to maladaptive exercise, as FOWG has been shown to increase following a binge episode [11]. A better understanding of differences in associations between FOWG and exercise by exercise type (maladaptive vs. adaptive) would allow us to better tailor interventions for individuals with EDs who are engaging in maladaptive exercise. However, no studies to date have accounted for the influence of exercise type on momentary associations between FOWG and exercise.

Thus, the current study aimed to examine between- and within-subject associations between exercise and FOWG as well as trajectories of FOWG around exercise episodes within a sample of individuals with binge eating.

Between-subject associations. A preliminary aim of the study was to replicate between-subject associations between FOWG and exercise engagement within the current sample. We hypothesized that overall exercise frequency would be significantly associated with higher FOWG and that this association would be moderated by exercise type such that FOWG will be more strongly associated with maladaptive exercise engagement.

Within-subject associations. Primary aims of this study were to (1) examine whether within-subjects momentary levels of FOWG at time1 were predictive of exercise behaviors at time2 and whether exercise at time1 was predictive of FOWG levels at time2. We hypothesized that increases in FOWG above an individual's mean at time1 would significantly predict engagement in exercise at time2. We also hypothesized that engagement in exercise at time1 would predict decreases in FOWG at time2. Further, we hypothesized that exercise type (maladaptive vs. adaptive) would moderate predictive associations between FOWG at time1 and exercise at time2, and exercise at time1 and FOWG at time2 such that FOWG levels will be more strongly associated with maladaptive exercise.

Trajectories of FOWG. Additionally, the current study aimed to examine trajectories of FOWG over the hours pre- and post-exercise. When examining trajectories of FOWG, we hypothesized that FOWG would increase leading up to exercise and decrease following exercise. Further, we hypothesized that exercise type would significantly moderate the pre- and post-exercise trajectories of FOWG such that increased levels of FOWG pre-exercise will be more strongly associated with maladaptive exercise.

Methods

Participants

We recruited adults with clinically significant binge eating ($N = 58$). Inclusion criteria for the current study included being 18 years of age or older, having experienced at least one binge eating episode (objective or subjective) per week on average for the past 12 weeks, possess a smartphone and are willing complete ecological momentary assessment (EMA) surveys, enrollment in a treatment study in the Center for Weight Eating and Lifestyle Sciences (WELL Center) and having at least 7 days before the first treatment session to complete the EMA protocol. Participants were also required to be located in the United States and be willing to participate in the remote intervention and assessments. Exclusion criteria were an inability to fluently speak, write, or understand English, BMI below 18.5, were intending on enrolling in, or currently enrolled in, another weight loss treatment or psychotherapy for eating disorders in the next 16 months, or other severe psychopathology (e.g., active psychotic disorder, severe depression, or substance

dependence) or intellectual disability that would limit their ability to participate fully in a treatment program.

Procedures

Recruitment. This study recruited participants from the United States. Once a participant was deemed eligible for an eating disorder treatment study, they were offered the option to participate in the study. Participants were then consented and contacted by study staff to set up the EMA smartphone application they would utilize throughout the study. All study procedures were approved by the Drexel University Institutional Review Board.

Ecological Momentary Assessment Surveys. The current study included two types of EMA surveys, signal contingent (i.e., a semi-randomly timed survey that participants completed following a smartphone notification), and event contingent (i.e., a self-initiated survey completed after engagement in binge eating, laxative/diuretic use, or self-induced vomiting). Participants received six daily, signal-contingent EMA surveys that were semi-randomly distributed over the day (i.e., approximately three in the morning and three in the evening).

Measures

Eating pathology. The Eating Disorders Examination 17.0 (EDE) is a validated semi-structured diagnostic interview that is utilized to assess participant's eating pathology over the past three months [12]. The EDE was used to classify objective and subjective binge eating episodes. Objective binge episodes were classified as episodes of eating where the amount of food eaten was considered "objectively large" per the EDE and loss of control was present. Subjective binge eating episodes were classified as episodes of eating where the amount of food was not considered "objectively large," but the participant viewed the amount of food to be excessive and loss of control was present. The EDE was also used for diagnostic purposes in the current study.

Exercise. Exercise was assessed at each survey using the question "Have you exercised since the last survey?" Participants answered using a Yes/No answer choice.

Exercise type. If participants endorsed exercising since the last survey, they were then asked, "To what extent did you feel driven or compelled to exercise?", and "To what extent did you exercise to compensate for eating?" A five-point Likert scale from 0 ("Not at all") to 4 ("Extremely") was utilized to answer both questions and maladaptive exercise was defined as an endorsement of $\geq 3/5$ on either question. Adaptive exercise was defined as $< 3/5$ on both questions assessing exercise type.

Fear of weight gain. FOWG was assessed at each survey using the question "Right now, to what extent are you afraid of gaining weight?" A five-point Likert scale from 0 ("Not at all") to 4 ("Extremely") was used to answer this question.

Statistical analyses

Between-subject associations between FOWG and exercise. SPSS Version 26 was used for all analyses. Linear regression was used to examine the association between overall exercise frequency and within-person levels of FOWG. A second model included an interaction term for FOWG and exercise type (maladaptive vs. adaptive).

Within-subject associations between FOWG & exercise. Generalized estimating equation (GEE) models using a negative binomial distribution with a logit link function and a first-order autoregressive matrix structure were utilized to examine whether momentary elevations in FOWG predicted engagement in exercise at the subsequent survey. In order to examine if momentary engagement in exercise predicted elevations in FOWG at the subsequent survey, GEE models used a linear distribution and a first-order autoregressive matrix structure. Additional models included an interaction term of FOWG and exercise type (adaptive vs. maladaptive). Between-subject effects were included in all models (e.g., participants' mean levels across recording period) for FOWG (e.g., between-subject FOWG levels). All models controlled for diagnosis and prior binge episodes. Within-subject effects were centered within person and between-subject variables were grand mean centered.

Trajectories of FOWG Around Exercise Episodes. Pre- and post-exercise trajectories of FOWG were modeled separately using piecewise linear, quadratic, and cubic functions centered on the time of exercise. We used multilevel models where momentary observations (Level 1) were set within subjects (Level 2) to estimate linear ([time prior/following the exercise]), quadratic ([time prior/following the exercise]^2), and cubic ([time prior/following the exercise]^3) effects. A common intercept for pre- and post-exercise trajectories and a random intercept for subject was specified by these models. For pre-exercise trajectories, analyses examined whether the effects (linear, cubic, and quadratic) differed significantly from zero. For post-exercise trajectories, analyses examined if the effects (linear, cubic, and quadratic) of post-exercise trajectory were significantly different from the pre-exercise trajectory. Effects were converted to standardized beta-weight values (β) to aid interpretation. A first-order autoregressive covariance structure (ARI) was used to account for serial correlations. To estimate parameters, the maximum-likelihood estimation method was used.

Results

Sample descriptives

The sample (82.9% female) included 58 adults (M_{age} = 44.07, SD = 13.78) with trans-diagnostic binge eating and mean BMI = 35.31 (SD = 8.27). Participants primarily identified as Caucasian (86.4%) with others identifying as African American (10.2%), or unknown or prefer not to say (3.4%); 13.5% identified as Hispanic or Latino. At baseline, participants endorsed an average of 24.23 (SD = 16.92) binge episodes and 6.70 (SD = 15.35) compensatory behaviors over the past month. Fifteen participants (26.3%) were diagnosed with bulimia nervosa (BN), 27 (47.4%) with binge eating disorder (BED), and 15 (26.3%) with sub-threshold BN or BED (i.e., experienced primarily subjective binge episodes).

Participants reported a total of 448 exercise episodes, with an average of 7.7 (SD = 8.35) exercise episodes endorsed per participant over the recording period. Forty-six participants (79.3%) endorsed at least one episode of maladaptive exercise and participants with maladaptive exercise endorsed an average of 5.88 (SD = 8.67) episodes of maladaptive exercise across the EMA period. A total of 706 antecedent FOWG ratings (M = 2.57, SD = 1.21) and 617 consequent FOWG ratings (M = 2.46, SD = 1.27) were reported relative to within-day exercise episodes. See Table 1 for further description of exercise episode types. Average participant compliance (i.e., percent signal-contingent ratings completed for each prompt), was 87.8%, which is similar to previous EMA work within ED samples [13, 14]. Participants completed the protocol for an average of 11 days (SD = 2.79).

Table 1 Number (*N*) and percent (%) of exercise episode types

Exercise episode type	*N*	%
Driven only	116	25.9
Compensatory only	9	2.0
Driven and compensatory	100	22.3
Adaptive	223	49.8

Between-subject associations between FOWG and exercise

Exercise frequency accounted for 10.4% of the variance in FOWG (β = 0.380, $t(812)$ = 9.79, $p < 0.001$, sr^2 = 0.104) when accounting for variance explained by diagnosis and binge episode frequency (model R^2 = 0.117, $F(3, 812)$ = 35.81, $p < 0.001$). When the interaction term of exercise frequency and type (maladaptive vs. adaptive) was added to the model, it explained an additional 1.6% of the variance in FOWG (model R^2 = 0.133, $F(4,811)$ = 31.07, $p < 0.001$). In this model, the interaction of exercise frequency and type accounted for 1.7% of the variance in FOWG (β = 0.403, $t(811)$ = 3.87, $p < 0.001$, sr^2 = 0.017). See Fig. 1 for a representation of the interaction between exercise frequency and type on FOWG.

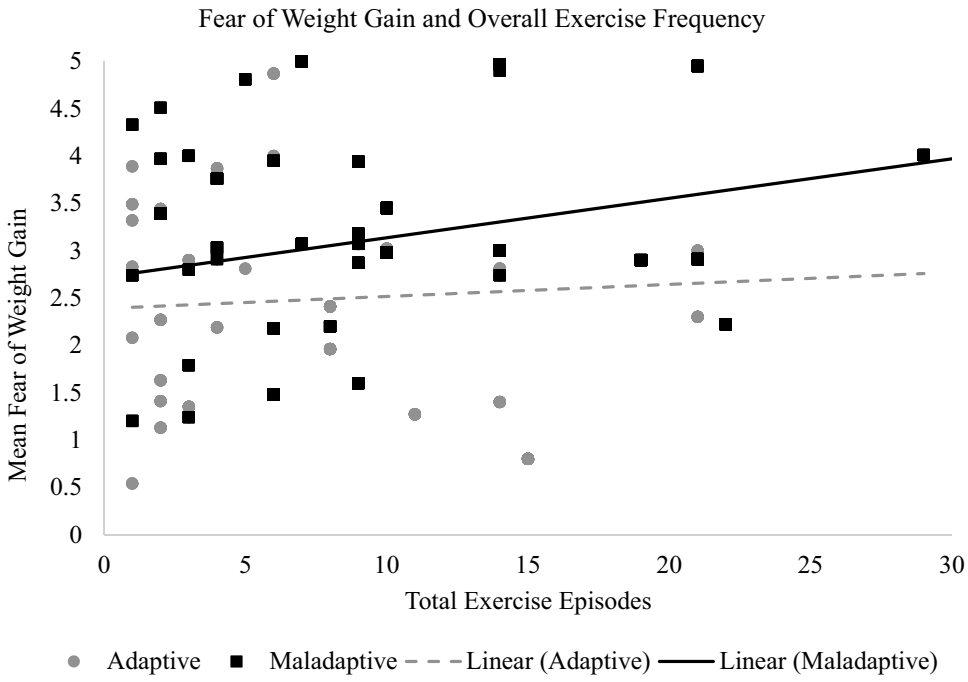

Fig. 1 Between-subject associations between FOWG and exercise engagement among individuals with binge-spectrum EDs by exercise type (maladaptive vs. adaptive)

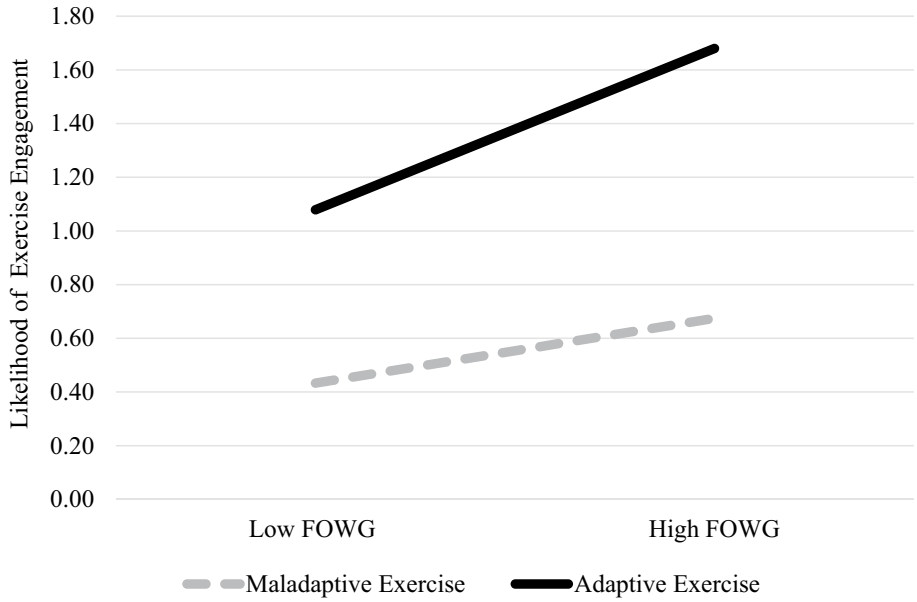

Fig. 2 Moderating effect of exercise type on likelihood of exercise engagement following increases in FOWG

Table 2 Predictive relationships between exercise engagement and changes in FOWG
*($p < 0.05$)

Predictor	Outcome	Moderator	*B*	*S.E*	*p*	OR
FOWG	Exercise	–	0.207	0.313	0.51	1.23
		Exercise type	−0.882	0.350	0.01*	0.414
Exercise	FOWG	–	−0.008	0.026	0.75	–
		Exercise type	0.010	0.051	0.84	–

Within-subject associations between FOWG and exercise

Within-subject levels of FOWG did not significantly predict exercise engagement at the next survey ($\beta = 0.207$, $SE = 0.313$, $p = 0.51$) however, this relationship was significantly moderated by exercise type ($\beta = -0.882$, $SE = 0.350$, $p = 0.01$, $OR = 0.414$) such that within-subjects levels of FOWG were significantly associated with adaptive exercise episodes (Fig. 2). There was no association between engagement in exercise at time1 and decreases in FOWG at time2, nor did exercise type moderate the relationship. See Table 2 for further details on predictive analyses.

Trajectories of fear of weight gain around exercise episodes

There was no significant effect of FOWG pre- or post-exercise, and exercise type did not moderate the trajectory of FOWG pre- or post-exercise (Table 3 and Fig. 3).

Table 3 Results of analyses examining trajectories of FOWG pre- and post-exercise and trajectories of FOWG moderated by exercise type (i.e., maladaptive vs. adaptive)

Moderator	Time period	Trajectory	*B*	*p*
None	Pre-exercise	Linear	0.007	0.46
		Quadratic	−0.001	0.11
		Cubic	< 0.0001	0.64
	Post-exercise	Linear	0.002	0.90
		Quadratic	0.002	0.06
		Cubic	−0.0002	0.07
Exercise Type	Pre-exercise	Linear	−0.0008	0.97
		Quadratic	−0.001	0.41
		Cubic	0.0001	0.36
	Post-exercise	Linear	0.014	0.63
		Quadratic	−0.001	0.53
		Cubic	−0.0002	0.58

Discussion

The current study aimed to examine associations between exercise and FOWG within a sample of individuals with binge eating. A preliminary aim of the study was to replicate

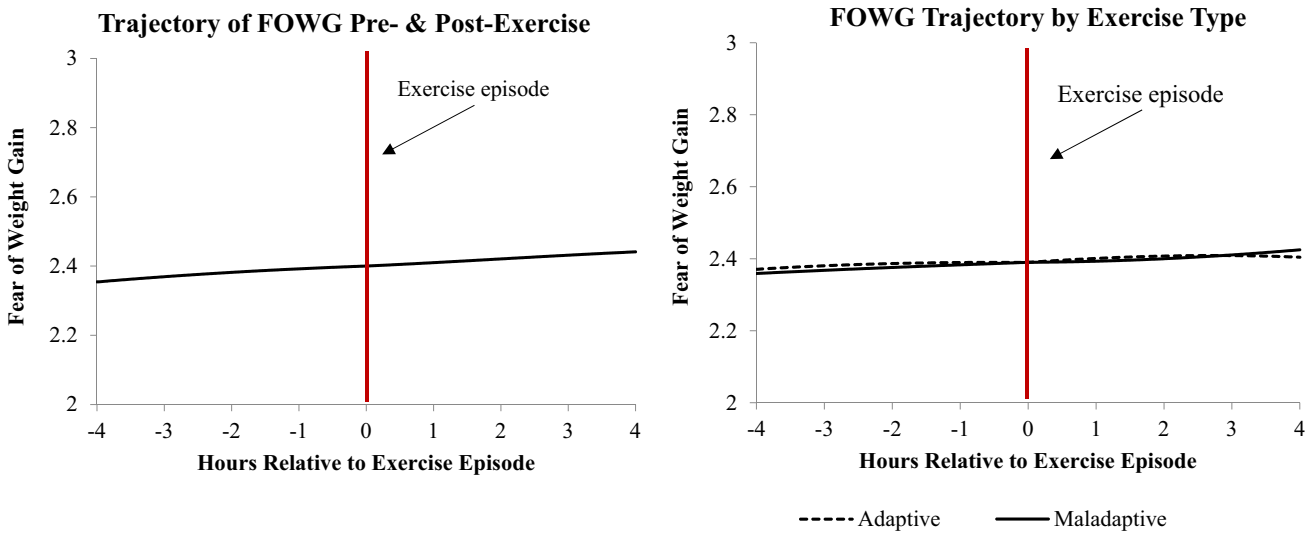

Fig. 3 Trajectory of FOWG pre- and post-exercise (left) and trajectories of FOWG for maladaptive and adaptive exercise episodes separately (right)

long-term associations between FOWG and exercise engagement within the current sample. Primary aims of this study were to (1) examine whether momentary changes in FOWG were predictive of exercise behaviors and whether exercise was predictive of changes in FOWG, and (2) examine trajectories of FOWG pre- and post-exercise in this sample.

Between-subject associations between FOWG and exercise

While we observed that higher frequency of exercise was associated with higher levels of FOWG across the sample, which is consistent with findings from Slof-Op't and colleagues [8] indicating that higher levels of FOWG were associated with higher exercise frequency. An interaction term of exercise frequency and type (maladaptive vs. adaptive) uniquely explained 1.7% of the variance in FOWG levels. Although this is a small effect size, this finding indicates that the relationship between FOWG and overall exercise frequency may be stronger for those engaging in maladaptive exercise. It is possible that maladaptive exercise engagement may be intended to regulate FOWG, but rather than attenuating FOWG, maladaptive exercise actually further reinforces a focus on weight and shape in self-evaluation. As a result, maladaptive exercise engagement may maintain increased levels of FOWG.

Within-subject associations between FOWG and exercise

Overall, we did not observe a relationship between FOWG and subsequent exercise engagement. This finding is contrary to both between-subject findings as well as previous cross-sectional studies which have found that increased FOWG was associated with increased vigorous exercise engagement [9]. However, differing relationships between FOWG and exercise engagement by exercise type (maladaptive vs. adaptive) may explain this pattern of results. Unexpectedly, the observed predictive associations suggest that the momentary relationship between FOWG and exercise engagement is strongest for adaptive exercise episodes. Specifically, we observed that individuals were overall slightly more likely to engage in exercise following increased FOWG (although this did not reach statistical significance), but this relationship was most prominent for those engaging in adaptive exercise compared to maladaptive exercise. This finding is surprising given established cross-sectional associations between FOWG and compulsive exercise engagement [10]. It is possible that FOWG may need to be experienced over a longer time period before it might precipitate maladaptive exercise engagement. In the current study, time1 and time2 were only 2–3 h apart, which may not be long enough for individuals to be exercising in response to sustained increases in FOWG. Alternatively, FOWG may fluctuate on a much smaller timescale, thus after several hours individuals may no longer be experiencing increased FOWG, potentially making them more likely to engage in adaptive exercise at time2. Finally, because many individuals may plan their exercise routines at the start of the day, it is possible that changes in FOWG may not influence the maladaptive or adaptive nature of exercise on a momentary level. Future research should examine whether FOWG is associated with exercise plans or intentions. Based on these findings, it is also possible that individuals with EDs may be engaging in maladaptive exercise

for reasons other than increased FOWG. However, as EMA is a self-report methodology, it is possible that individuals may have under-/over-reported maladaptive exercise, thus influencing observed associations.

Trajectories of fear of weight gain around exercise episodes

Additionally, we did not find any significant trajectory of FOWG pre- or post-exercise, and the type of exercise did not moderate trajectories of FOWG pre- or post-exercise. Consistent with predictive associations, these findings suggest that exercise engagement, regardless of type, does not effectively regulate momentary changes in FOWG. This may be a beneficial addition to psychoeducation around adaptive and maladaptive exercise in current treatments for EDs, however, it is important to note that this finding does not completely rule out a regulation function of exercise on FOWG. It is possible that the modest sample size and the self-report nature of EMA may contribute to the observed effects.

Clinical implications and future directions

Overall, the results from this study provide promising clinical implications and highlight important areas for continued research. First, we found that higher levels of maladaptive exercise seem to be associated with higher between-subject levels of FOWG. This finding highlights the importance of addressing the function, and reducing the frequency, of maladaptive exercise. Similar to the results from Lampe et al. [5] which found heterogeneous reasons for exercise engagement, the current study suggests that some specific reasons for exercise, such as exercising to decrease heightened FOWG, may maintain maladaptive exercise. Thus, directly addressing the function of maladaptive exercise may be essential for improving treatment outcomes for individuals that present to treatment engaging in maladaptive exercise. Future interventions should continue to identify risk factors for maladaptive exercise episodes. Better identification of specific risk factors for maladaptive exercise would allow novel treatments such as just-in-time-adaptive-interventions to pre-emptively intervene when individuals are at high risk for maladaptive exercise engagement. For example, if the hour after mealtimes is a high-risk time for engaging in maladaptive exercise, a push notification could be sent to individuals 1 to 2 h following a reported meal to intervene on the maladaptive exercise behavior. Second, we found that exercise engagement does not seem to serve to regulate FOWG at a momentary level, which could be beneficial psychoeducation for patients engaging in high levels of maladaptive exercise. Future research should aim to identify when, and for whom, exercise may serve to regulate FOWG to further refine future treatment approaches. Additionally, based on recent work by Scharmer et al. [15], which suggests exercise with compulsive qualities (i.e., exercise to control shape and weight) is more strongly associated with ED severity compared to exercise with dependent qualities (i.e., avoidance of exercise withdrawal), it is possible one specific quality of exercise (i.e., compulsivity vs dependence) is more strongly linked to regulating FOWG. Further, future research should examine other potential functions of exercise for individuals with EDs to enhance the fields' understanding of the role that both adaptive and maladaptive exercise play in maintaining ED pathology.

Strength and limits

Several strengths must be highlighted from the current study. First, and most notable, this study expands on the limited literature base of both exercise and FOWG in EDs and highlights the importance of conducting empirical research on these topics. Second, we were able to use EMA technology to assess FOWG at a momentary level, resulting in both increased observations of exercise and FOWG as well as increased ecological validity of those observations. Third, the use of EMA also allowed us to demonstrate the temporal associations between changes in FOWG and exercise engagement. Finally, our use of mixed models to examine trajectories of FOWG around exercise episodes allowed us to rigorously assess FOWG-regulation as a function of exercise.

Despite the many strengths of the current study, there are limitations that should be considered. First, while the sample size is similar to other EMA studies which assessed ED behavior engagement [14, 16], the modest sample size limits the total number of exercise episodes that we were able to capture. Second, the current study did not use event-contingent EMA recordings of exercise episodes, which may have reduced the number of recordings overall, and especially reduced the number of FOWG ratings immediately following exercise engagement. Third, the trajectory analyses were unable to accommodate multiple exercise episodes within a single day. To reduce covariance of FOWG and exercise, we only included the first exercise episode of each day [17]; however, it may be that individuals who exercise more than once per day may display differing trajectories of FOWG surrounding each exercise episode. Lastly, although repeated assessment via EMA technology can evaluate temporal precedence, other explanatory causes must still be considered for the observed relationships between FOWG and exercise. As a result, causality should not be inferred from these results.

What is already known on this subject?

Maladaptive exercise is thought to momentarily down-regulate elevated FOWG. Thus, FOWG is thought to maintain engagement in maladaptive exercise through negative reinforcement. However, little research has examined associations between FOWG and exercise, and no research has measured FOWG at a momentary level or considered how exercise type (i.e., maladaptive vs. adaptive) may affect these associations.

What this study adds?

Overall, findings of the current study indicate that momentary changes in FOWG are more strongly associated with adaptive exercise, while greater maladaptive exercise engagement is associated with higher levels of FOWG. Future clinical interventions should aim to identify risk factors for engagement in maladaptive exercise and should include psychoeducation that exercise engagement does not seem to meaningfully regulate increases in FOWG. Future research should examine when, and for whom with EDs, exercise may be associated with FOWG.

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Availability of data and material Data is available upon request to the corresponding author.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no conflicts of interest to report.

Ethics approval All study procedures were approved by the Drexel University Institutional Review Board.

Consent to participate All participants provided informed consent for their participation.

Consent for publication Not applicable.

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