

Eating disorder fear networks: Identification of central eating disorder fears

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Abstract

Objective: Eating-related fear and anxiety are hallmark symptoms of eating disorders (EDs). However, it is still unclear which fears are most important (e.g., food, weight gain), which has practical implications, given treatments for eating-related fear necessitate modifications based on the specific fear driving ED pathology. For example, exposure treatments should be optimized based on specific fears that maintain pathology. The current study ($N = 1,622$ combined clinical ED and undergraduate sample) begins to answer questions on the precise nature of ED fears and how they operate with other ED symptoms.

Method: We used network analysis to create two models of ED fears and symptoms. The first model consisted of ED fears only (e.g., fears of food, fears of weight gain) to identify which fear is most central. The second model consisted of ED fears and ED symptoms to detect how ED fears operate with ED symptoms.

Results: We found *fear of disliking how one's body feels due to weight gain, disliking eating in social situations, feeling tense around food, fear of judgment due to weight gain, and food anxiety* were the most central ED fears. We also identified several bridge symptoms between ED fears and symptoms. Finally, we found that the most central ED fears predicted excessive exercise at two-month follow-up.

Discussion: These data support the idea that consequences (i.e., judgment) associated with fears of weight gain and interoceptive fears are the most central ED fears. These data have implications for the future development of precision interventions targeted to address ED-related fear.

KEYWORDS

anxiety, eating disorders, fear, fear of weight gain, network analysis

1 | INTRODUCTION

Fear and anxiety are central to eating disorder (ED) pathology (Murray et al., 2018). EDs co-occur with anxiety disorders at strikingly high rates (>80%), share overlapping phenotypic similarities, and have a strong genetic correlation with anxiety disorders and obsessive-compulsive disorder (OCD; Bulik et al., 2007; Mas et al., 2013; Strober, Freeman, Lampert, & Diamond, 2007; Swinbourne & Touyz, 2007). Furthermore, neurobiological research in anxiety and

ED shows deficits in fear expression and fear extinction areas of the brain (e.g., Fullana et al., 2016; Pittig, Treanor, LeBeau, & Craske, 2018). Despite the centrality of fear and anxiety, it is unknown which specific fears are most central to ED psychopathology, as well as how ED-specific fears interact with other symptoms of the disorder. For example, fears of food have been widely studied (Levinson et al., 2019; Levinson, Brosf, Ma, Fewell, & Lenze, 2017; Levinson & Byrne, 2015; Steinglass et al., 2012; Steinglass et al., 2014), and fears of weight gain (Levinson et al., 2017; Levinson, Rapp, & Riley, 2014;

Linardon et al., 2018) have been theorized as hallmark symptoms, yet there is little quantitative work explicating how these fears function to maintain EDs. Importantly, ED fear is hypothesized to be important regardless of ED diagnosis (Forrest, Jones, Ortiz, & Smith, 2018; Goldschmidt et al., 2018; Levinson et al., 2018; Meier et al., 2020; Vanzhula, Calebs, Fewell, & Levinson, 2019).

Precise understanding of how ED fears function as symptoms of ED pathology has important clinical relevance, as ED-specific fears, such as fear of food, are related to caloric restriction and less meal plan adherence, which increases the odds of negative treatment outcomes and chronic course of EDs (Levinson & Byrne, 2015; McFarlane, Olmsted, & Trottier, 2008). Treatments designed to disrupt connections among ED-related fears, such as exposure therapy, could be optimized based on greater understanding of how these fears maintain ED pathology (Levinson et al., 2017; Levinson & Byrne, 2015; Steinglass et al., 2012). For example, if research shows that fears of “food” versus fears of “weight gain” are central to the conceptualization of ED psychopathology, exposure therapies should be modified to focus on fears related to food, rather than weight-related fears. Furthermore, there has been some debate on if exposure therapy can be successful in the context of weight restoration if the primary ED fear is fear of weight gain (e.g., the patient is inevitably gaining weight and approaching their feared outcome), leading to a call for more research explicating which fears maintain ED pathology (Murray, Loeb, & Le Grange, 2016).

One of the primary reasons that the field knows little about ED-related fears is due to the limited assessment and methodological tools available to capture such fears. For example, in the social anxiety disorder (SAD) literature there has long been several “gold standard” measures in existence for the characterization of social fears (e.g., Liebowitz, 1987; Mattick & Clarke, 1998). Recently, researchers in the ED field have developed assessment tools characterizing ED-fear. Specifically, recent work developed measures that assess both “fears of food” and overall “ED-related fears” (Levinson & Byrne, 2015; Levinson, Vanzhula, & Christian, 2019). Both measures were developed to help improve understanding of eating-related anxiety and fear using psychometrically strong assessment of these constructs. The Fear of Food Measure (FOFM; Levinson & Byrne, 2015) was created to assess cognitive-behavioral fears of food, food avoidance behaviors, and feared concerns around eating and food. The eating disorder fear questionnaire (EFQ; Levinson, Vanzhula, & Christian, 2019) was developed to assess general eating-disorder fears and captures five aspects of ED fears: fears of weight gain, fears of physical sensations, fears of social consequences, fears of personal consequences, and fears of social eating. Both of these measures have good factor, convergent, divergent, and construct validity and provide novel tools to assess ED-related fears (Levinson & Byrne, 2015; Levinson, Vanzhula, & Christian, 2019).

Network analysis (NA) is a methodology that allows for a more precise characterization of how symptoms operate among systems of psychopathology (Borsboom, 2017; Borsboom & Cramer, 2013). Using NA, classification of “most important,” or central symptoms is possible (Borsboom & Cramer, 2013; Borsboom, Cramer, Schmittmann, Epskamp, & Waldorp, 2011). These symptoms are based on *network theory's* proposition that symptoms with high

centrality impact the most symptoms in the network and may function as “maintaining” factors of psychopathology (pending experimental research) (Borsboom et al., 2011), meaning the symptoms that are most important to the maintenance of psychopathology can be identified (though to date most *empirical* research has been cross-sectional showing associations among symptoms). Supporting this theory, recent research has shown that central symptoms predict treatment outcomes (e.g., depression, anxiety, and body mass index) both in the EDs and other related conditions (Brown et al., 2020; Meier et al., 2020; Olatunji, Levinson, & Calebs, 2018) and are the most heritable symptoms (Olatunji, Christian, Strachan, & Levinson, 2020). Based on this premise and empirical data, network theory proposes that central symptoms may serve as important intervention targets. NA in the ED field have found that fears of weight gain and overvaluation of weight and shape are central symptoms in ED psychopathology (Dubois, Rodgers, Franko, Eddy, & Thomas, 2017; Forbush, Siew, & Vitevitch, 2016; Forrest et al., 2018; Goldschmidt et al., 2018; Levinson et al., 2017) and may be targets for novel intervention development. Indeed, prior NA have found fear, such as fear of weight gain, as central to ED pathology (Elliott, Jones, & Schmidt, 2020a; Forrest et al., 2018; Goldschmidt et al., 2018; Levinson et al., 2017; Levinson, Brosos, et al., 2018; Meier et al., 2020; Vanzhula et al., 2019). While these prior networks include a one item assessment of fear of weight gain, they did not include comprehensive assessment of ED fears, including associated consequences (e.g., rejection) of fear of weight gain. No research has included comprehensive measurement of ED fears in a network model, despite the central nature of anxiety and fear to EDs. In other words, NA can be used to identify which ED fears are most central both within the context of other eating-related fears and including ED symptoms as a whole.

In addition to quantification of the centrality of psychopathology symptoms, NA provides characterization of unique pathways among symptoms, as well as “bridge” symptoms, among different forms of psychopathology. For example, recent research has used NA to delineate symptoms that connect between EDs and anxiety, depression, SAD, and PTSD (Levinson et al., 2017; Levinson, Brosos, et al., 2018; Vanzhula et al., 2019). Bridge symptoms are theorized to be pathways between illnesses that cause disorders to co-occur and/or spread from one type of psychopathology to another (Borsboom, 2017). Regarding ED fears, bridge symptoms can be used to define how ED fears interrelate with other aspects of ED pathology, leading to the maintenance and persistence of EDs and related fear and anxiety.

With the development of psychometrically strong measures of ED-related fears and novel NA methodologies, characterization of how ED-related fears operate with each other and with overall ED symptomatology is now possible. Therefore, the current study ($N = 1,622$ combined clinical ED and undergraduate sample) aimed to develop a network model of (a) ED-related fears to determine which fears are most central and (b) ED-related fears and overall ED symptoms to characterize how ED-related fears interrelate with overall ED pathology. We tested ED fears in a transdiagnostic sample, given the transdiagnostic nature of fear and anxiety in EDs (e.g., Forbush et al., 2017; Trompeter et al., 2019). In network theory, central

symptoms are thought to impact the most other symptoms in the network, and thereby serve a crucial role in the maintenance of pathology. Thus, we also sought to test if centrally-identified symptoms would predict outcomes at a two-month follow-up. We utilized a combined clinical and non-clinical sample because both ED symptoms (Wildes & Marcus, 2013) and fear have been shown to be dimensional (Clark & Watson, 2006; Kotov et al., 2017), to increase power, to allow for inclusion of a wider number of ED fears, and because prior NA research has supported similar structure in ED pathology across clinical and non-clinical samples (e.g., Forrest et al., 2018). We ensured that the samples were equivalent using tests of network comparison. We hypothesized, based on prior NA research (DuBois et al., 2017; Forbush et al., 2016; Goldschmidt et al., 2018; Levinson et al., 2017), that fears of weight gain would be central in an ED fear network, and that overvaluation of weight and shape would be central within a network including overall ED symptoms and fears. We also hypothesized that fears of weight gain and overvaluation of weight and shape would bridge between ED fears and ED symptoms. Finally, based on prior work finding that central symptoms predict clinical outcomes (Brown et al., 2020; Olatunji et al., 2018), we hypothesized that the most central symptoms would predict ED behaviors (e.g., fasting, excessive-exercise) at two-month follow-up.

2 | METHODS

2.1 | Participants

2.1.1 | Clinical sample ($n = 229$ ED)

Most participants (94.8%) were women ($n = 217$) between the ages of 15 and 66 ($M = 29.24$, $SD = 10.25$). Ethnicities reported were White (75.1%), Hispanic (4.8%), Asian-American (2.2%), multiracial (2.2%), African-American (1.3%), not listed (.09%), or did not report (13.5%). Regarding ED diagnosis, 31.4% of participants had AN, 18.8% BN, 7.8% BED, 41.1% OSFED (32.3% atypical AN, 5.7% atypical BN, and 3.1% atypical BED), and 0.9% ARFID.

2.1.2 | Undergraduate sample ($n = 1,393$)

Most participants were women ($n = 1,088$; 78.1%). Ages ranged between 16 and 70 ($M = 19.99$, $SD = 3.99$). Ethnicities reported were White (66.8%), Black (14.6%), Multiracial (5.4%), Asian (5.9%), Hispanic (4.1%), American-Indian (0.5%), and not listed (2.2%).

2.2 | Procedure

2.2.1 | Sample 1: Clinical

Individuals with EDs were recruited to participate in an online-based treatment. Participants were included in the study if they had a

current ED diagnosis via structured clinical interview completed by the PI or a PhD student. All diagnoses were double-checked by four independent raters with diagnostic agreement on 93% of cases, 7% of cases were re-reviewed by the PI and discussed to reach consensus. Participants completed self-report measures at two time points approximately two-months apart. Networks were computed from baseline data before completing any aspect of treatment, and regressions were computed using baseline and two-month follow-up data to test for prediction of clinical outcomes. All participants received the same treatment. All procedures contributing to this work described comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

2.2.2 | Sample 2: Undergraduate

Undergraduates were recruited from a university-wide study portal for course-credit. Participants were consented online, and participants completed all measures described below via a secure, university-provided online questionnaire service. The validity of answers is assessed using "attention check" questions, such as "The grass is green, true or false?" The mean score for the EDE-Q global was 1.72 ($SD = 1.23$, $Range = 0-5.90$). The sample of 30.40% was at or above the cut-off score of 2.3 on the EDE-Q, which is indicative of clinical levels of ED (Mond, Hay, Rodgers, Owen, & Beumont, 2004).

2.3 | Measures

2.3.1 | EDE-Q 4.0

The EDE-Q (Fairburn & Beglin, 1994) assesses the severity and frequency of ED symptoms across the past 4 weeks. The EDE-Q has been shown to have good reliability and validity (Mond et al., 2004). The frequency items (i.e., binge eating, purging, laxative use, diuretic use, and excessive-exercise) collected at 2-month follow-up were used in regression analyses in order to measure the predictive abilities of the most central items. The EDE-Q had excellent internal consistency ($\alpha = .95$).

2.3.2 | EFQ

The EFQ (Levinson, Vanzhula, & Christian, 2019) is a 30-item self-report measure used to assess ED-related-fears at time of assessment utilizing a 7-point Likert scale ranging from 1 (not at all) to 7 (very much so). The EFQ has five subscales: Fear of Weight Gain (I fear gaining weight), Fear of Social Consequences (I am afraid that I will not look perfect), Fear of Personal Consequences (I fear that if I over-eat I will become lazy), Fear of Physical Sensations (I worry that I will not like how my body feels if I gain weight), and Fear of Social Eating (I am afraid of eating in public). We included 18-items of the EFQ in NA. The EFQ had excellent internal consistency ($\alpha = .97$).

2.3.3 | FOFM

The FOFM (Levinson & Byrne, 2015) is a 25-item self-report measure used to measure eating-related-fears at time of assessment. The measure uses a 7-point Likert scale ranging from 1 (not at all characteristic) to 7 (very much characteristic). The FOFM has three subscales: Anxiety about Eating (I feel anxious when I eat), Feared Concerns (Eating makes me anxious because I am afraid I might get fat), and Food Anxiety Behaviors (There are certain foods I avoid because they make me anxious). This measure has good factor, convergent, divergent, and incremental validity (Levinson & Byrne, 2015). We included 24-items of the FOFM in our models. The FOFM had excellent internal consistency for the Anxiety about Eating subscale ($\alpha = .95$) and Food Concerns subscale ($\alpha = .92$), as well as good internal consistency for the Fear Anxiety Behaviors scale ($\alpha = .80$).

2.4 | Data analytic procedure

2.4.1 | Missing data

We found that 6.63% of the item level data were missing. Missing data were imputed using the multiple imputation methods in *MICE* package in R (Van Buuren & Groothuis-Oudshoorn, 2011) as is recommended for NA (i.e., Elliott et al., 2020a; Levinson, Brosof, et al., 2018). *MICE* conducts multiple imputation using Fully Conditional Specification (FCS) and Gibbs sampling. FCS creates separate models for the imputation of each individual variable by creating “plausible” values based on the other variables in the data set.

2.4.2 | Item selection

Items were selected using a combination of theory and the *goldbricker* function from the *networktools* package in R (Jones, 2020) as in prior NA (i.e., Dubois et al., 2017; Elliott et al., 2020a). *Goldbricker* assesses whether two-items measure the same symptom construct by identifying overlapping correlations.

2.4.3 | NA

Two *Glasso* networks were estimated using the *estimateNetwork* function in the *bootnet* package in R (Epskamp & Fried, 2020). Network 1 included only the EFQ and FOFM items, used to identify central ED fears. Network 2 included the EFQ, FOFM, and EDE-Q items, used to identify central ED fears and symptoms and bridge symptoms among ED fears and ED pathology. Fears included in these networks have been found to be distinct, yet correlated fears, related to ED symptoms (Levinson, Sala, et al., 2019).

The *Glasso* function estimates partial correlations between nodes. In other words, this function measures the relationships between variables while accounting for all other relationships in the network. Spearman correlations were used to estimate networks as these correlations normally result in more stable networks (Epskamp & Fried, 2018). Stability

estimates of each network were calculated using the *bootnet* package in R (Epskamp & Fried, 2020). Values above .50 for a network are considered stable (Epskamp, Borsboom, & Fried, 2017).

Centrality metrics

We used strength as our index of centrality for all of our models because research shows that strength is the most stable and valid index of centrality (Epskamp & Fried, 2018). Though strength has limitations (e.g., Bringmann et al., 2019), it is currently recommended as the best centrality metric available.

Centrality difference tests

Centrality difference tests were conducted using the *bootnet* package (Epskamp & Fried, 2020) to determine whether certain symptoms were significantly more central than others. Based on the results of each of the centrality difference tests, the most central symptoms of each network, which were significantly more central than other symptoms, were included in the interpretation of our results. The number of symptoms included is determined by observable decreases in significantly different centrality coefficients between symptoms.

Bridge symptoms

Bridge symptoms were identified in Network 2 using the *bridge* function of the *networktools* package in R (Jones, 2020). This package allows the user to analyze groups, or clusters, of symptoms that are of interest to the user. There are two groups in Network 2: ED fears and ED symptoms. The *bridge* function (Jones, 2020) quantifies the partial correlations between nodes to produce two estimates of centrality: bridge strength and bridge expected influence to calculate connections between groups. Bridge strength is the sum of the absolute value of edges between a node and all other nodes that are not in the same group as the original node. Stability estimates of both bridge strength and bridge expected influence were estimated using the *bootnet* package (Epskamp & Fried, 2020). Bridge strength and bridge expected influence difference tests were also estimated using the *bootnet* package (Epskamp & Fried, 2020).

Network comparison tests

Networks were compared using the *NetworkComparisonTest* package in R (van Borkulo, 2019). Specifically, we compared the results of Network 1 between the undergraduate sample and the clinical sample, as well as the results of Network 2 between the two samples. Three estimates were obtained to analyze differences between networks: network invariance, global strength invariance, and edge invariance (van Borkulo, 2019). Network invariance measures if the *structures* of the networks differ by calculating the differences in maximum edge strength in the networks. In other words, does the overall conceptual model of all parts (e.g., nodes, edges) differ. Global strength invariance measures if the *overall connectivity* of both networks differ by calculating the sum of the edge strength in the networks. In other words, do the overall associations among edges differ. Edge invariance measures if *individual edges* differ between networks by calculating the differences between specified edges between nodes. In other words, this tests if there are any differences in edges among any nodes. In this test there may be a small number of non-meaningful differences. These tests

were used to determine if networks varied by sample type to determine if it was appropriate to combine a clinical and undergraduate sample.

2.4.4 | Multiple regression analyses

To test if central symptoms predicted outcomes in the clinical subsample of participants ($n = 229$), we created a composite variable of the most central symptoms from Network 1 to create a measure of “most-central-ED-

fears.” To create this index, we made a composite of the top five central symptoms in the ED fear network. We chose these symptoms because they were significantly more central than at least 60% of other symptoms in the network, thereby representing the overall “most” central symptoms of ED fear. We also created a composite of the five least central symptoms in the ED fear network. We then tested if these composites predicted ED behaviors (fasting, excessive-exercise, purging, binge eating, and restraint) and overall ED symptoms (EDE-Q global score) at two-month follow up, while accounting for levels of the outcome at Time 1.

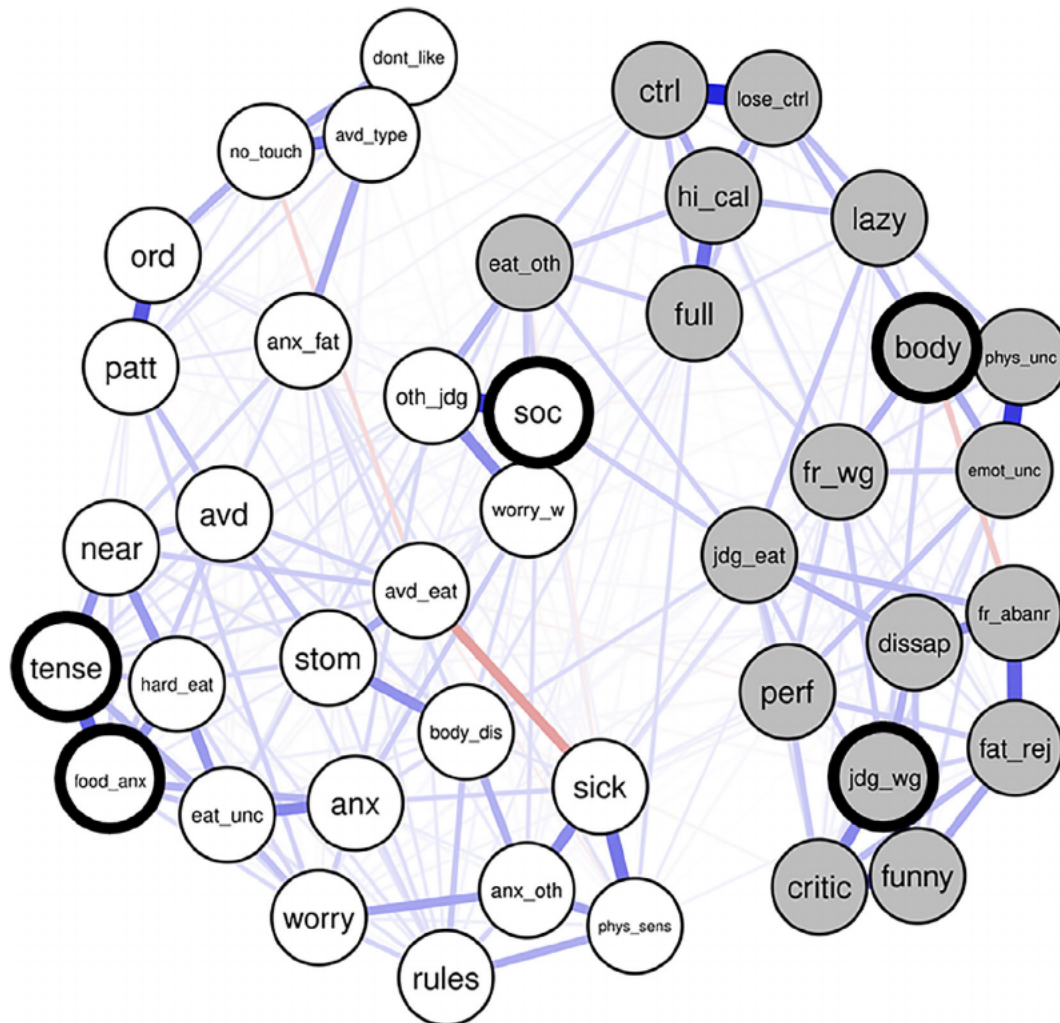


FIGURE 1 Eating disorder fear network (Network 1). fr_wg, fear of gaining weight, fr_aban, fear of abandonment by friends due to fatness; fat_rej, fear of rejection due to fatness; dissap, fear of disappointing others due to weight gain, jdkg_wg, fear of judgment due to weight gain; funny, fear of being looked at funny due to weight gain; critic, fear of being criticized due to becoming overweight; jdkg_eat, fear of being judged based on food choices; lazy, fear of laziness due to overeating; perf, ear of not looking perfect; emot_unc, fear of emotional discomfort due to weight gain; phys_unc, fear of physical discomfort due to weight gain; body, fear of disliking how one's body feels due to weight gain; eat_oth, fear of eating in front of others; hi_cal, fear of losing control if one eats high calorie foods; full, fear of gaining weight if one feels full; lose_ctrl, fear of losing control due to weight gain; ctrl, fear of losing control if one cannot control their eating; anx, eating anxiety; eat_unc, eating discomfort; tense, feeling tense around food, food_anx, food anxiety; worry, worry about eating; hard_eat, difficulty eating due to nervousness; near, disliking when food is nearby; avd, avoiding certain foods due to anxiety; patt, food rituals; ord, eating food in a certain order; dont_like, disliking certain foods; no_touch, not touching certain foods due to texture; avd_type, avoiding certain types of food; avd_eat, avoiding eating, rules, eating rules; anx_fat, eating anxiety due to fear of fatness; sick, eating anxiety due to fear of getting sick; stom, disliking eating due to the way one's stomach feels after eating; body_dis, eating anxiety due to fear of body dissatisfaction; anx_oth, public eating anxiety; oth_jge, public eating anxiety due to fear of judgment; soc, disliking eating in social situations; worry_w, limiting intake due to weight anxiety; phys_sens, physical discomfort while eating. Grey nodes indicate EFQ items. White nodes indicate FOFM items. Highlighted black nodes denote the most central symptoms [Color figure can be viewed at wileyonlinelibrary.com]

2.4.5 | Supplemental analyses in clinical subsample

Please see Table S1 for descriptive of all symptoms. In response to reviewer concerns regarding the suitability of undergraduates as a sample population we conducted post hoc analyses comparing these networks in an all clinical sample and in an all clinical combined with participants with high ED symptoms from the undergraduate sample. These materials are available in the supplemental online section in Table S2.

3 | RESULTS

3.1 | Network 1: ED Fear network

3.1.1 | Central symptoms

Network 1 was stable (strength stability = .75). Symptoms with the highest strength centrality were *fear of disliking how one's body feels due to weight gain* (EFQ; >65.75% of symptoms, *disliking eating in*

social situations (FOFM; >63.41% of symptoms, *feeling tense around food* (FOFM; >60.98% of other symptoms), *fear of judgment due to weight gain* (EFQ; >60.98% of other symptoms, and *food anxiety* (FOFM; >60.98% of other symptoms) (Figures 1 and 2). Strength centrality was not significantly related to variance in Network 1 ($r = .18$; $p = .260$).

3.1.2 | Network comparison tests (undergraduate vs. clinical)

The clinical sample ($n = 229$ ED) was compared with the undergraduate sample ($n = 1,393$). There was a significant difference in global strength invariance (Global strength invariance = .45, $p < .001$), but not significant network invariance ($p = .79$). These findings suggest that the overall connections between the symptoms were different, but the structures of the networks were similar. The edge invariance test indicated that 11.67% of the edges between the undergraduate and clinical networks were significantly different ($ps < .05$).

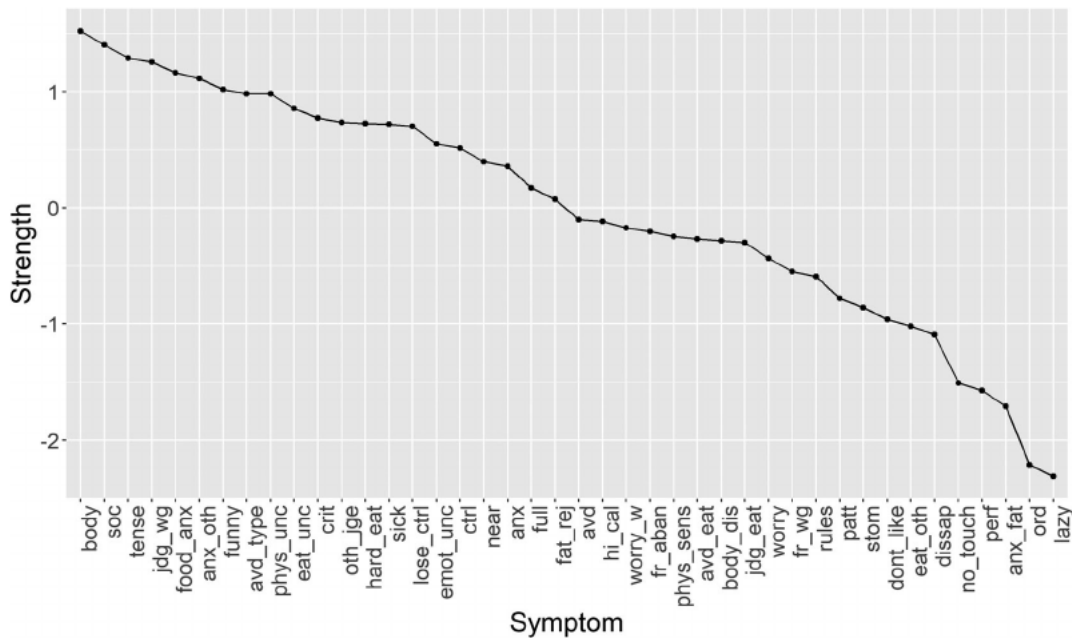


FIGURE 2 Eating disorder fear network (Network 1) centrality plot. fr_wg, fear of gaining weight, fr_aban, fear of abandonment by friends due to fatness; fat_rej, fear of rejection due to fatness; dissap, fear of disappointing others due to weight gain, jdg_wg, fear of judgment due to weight gain; funny, fear of being looked at funny due to weight gain; critic, fear of being criticized due to becoming overweight; jdg_eat, fear of being judged based on food choices; lazy, fear of laziness due to overeating; perf, fear of not looking perfect; emot_unc, fear of emotional discomfort due to weight gain; phys_unc, fear of physical discomfort due to weight gain; body, fear of disliking how one's body feels due to weight gain; eat_oth, fear of eating in front of others; hi_cal, fear of losing control if one eats high calorie foods; full, fear of gaining weight if one feels full; lose_ctrl, fear of losing control due to weight gain; ctrl, fear of losing control if one cannot control their eating; anx, eating anxiety; eat_unc, eating discomfort; tense, feeling tense around food, food_anx, food anxiety; worry, worry about eating; hard_eat, difficulty eating due to nervousness; near, disliking when food is nearby; avd, avoiding certain foods due to anxiety; patt, food rituals; ord, eating food in a certain order; dont_like, disliking certain foods; no_touch, not touching certain foods due to texture; avd_type, avoiding certain types of food; avd_eat, avoiding eating, rules, eating rules; anx_fat, eating anxiety due to fear of fatness; sick, eating anxiety due to fear of getting sick; stom, disliking eating due to the way one's stomach feels after eating; body_dis, eating anxiety due to fear of body dissatisfaction; anx_oth, public eating anxiety; oth_jge, public eating anxiety due to fear of judgment; soc, disliking eating in social situations; worry_w, limiting intake due to weight anxiety; phys_sens, physical discomfort while eating

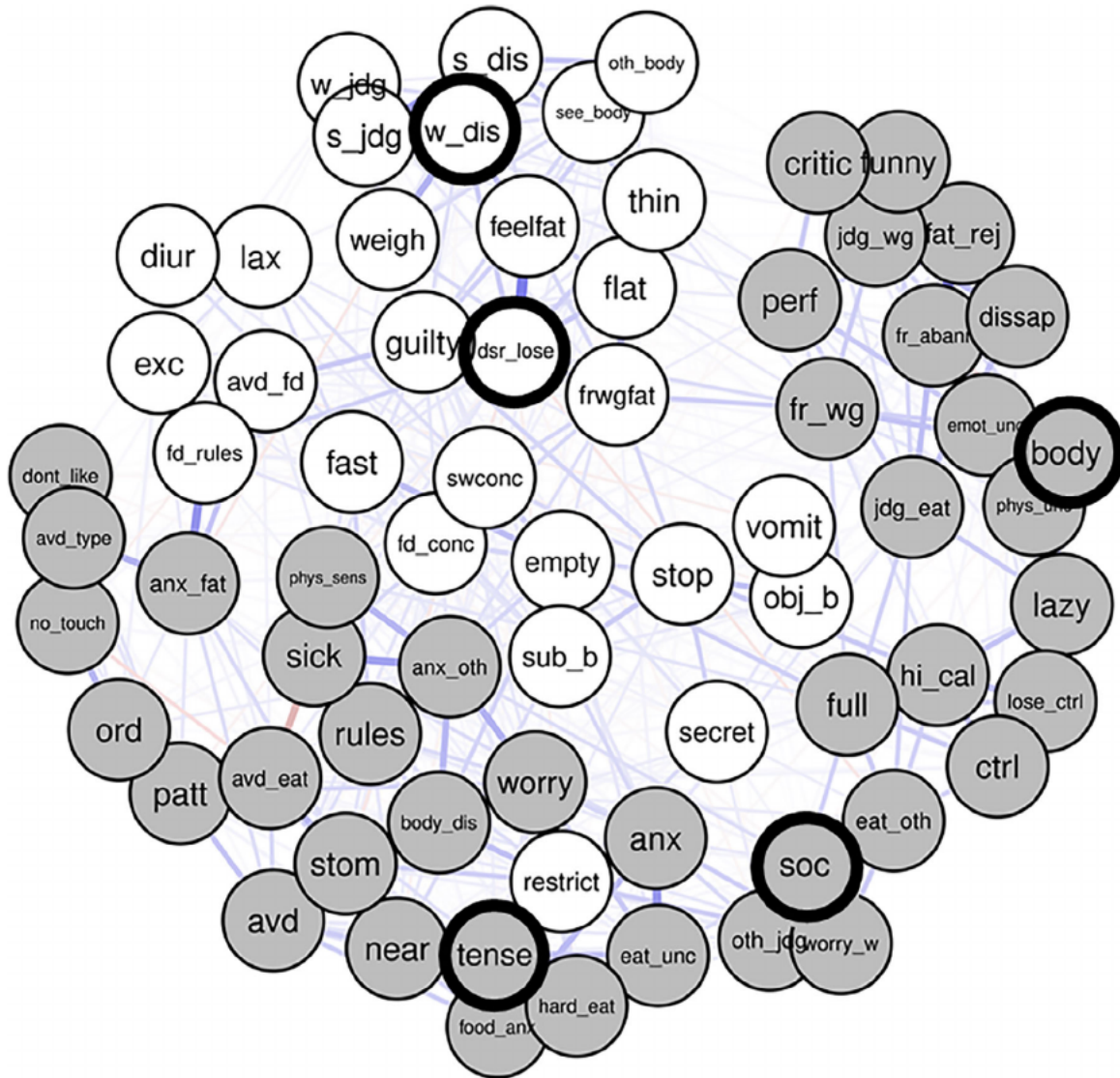


FIGURE 3 Eating disorder symptom and eating disorder fear network (Network 2). restrict, restriction; fast, fasting; avd_fd, avoiding foods; fd_rules, food rules fd_conc, difficulty concentrating due to thoughts of food/cal; stop, fear of not being able to stop or resist eating; secret, eating in secret; flat, desiring a flat stomach; empty, desiring an empty stomach; swconc, difficulty concentrating due to thoughts of weight/shape; frwgfat, fear of gaining weight or becoming fat; feel_fat, feeling fat; dsr_lose, desiring weight loss; guilty, feeling guilty because of shape/weight; obj_b, objective binge eating; subj_b, subjective binge eating; vomit, self-induced vomiting; lax, laxative use; diur, diuretic use; exc, excessive exercise; w_jge, judgment based on weight; s_jge, judgment based on shape; weigh, feeling distressed by weekly weighing; w_dis, weight dissatisfaction; s_dis, shape dissatisfaction; thin, desire for thinness; see_body, discomfort seeing one's own body; oth_body, discomfort with others seeing one's own body; fr_wg, fear of gaining weight, fr_aban, fear of abandonment by friends due to fatness; fat_rej, fear of rejection due to fatness; dissap, fear of disappointing others due to weight gain, jd_g_wg, fear of judgment due to weight gain; funny, fear of being looked at funny due to weight gain; critic, fear of being criticized due to becoming overweight; jd_g_eat, fear of being judged based on food choices; lazy, fear of laziness due to overeating; perf, fear of not looking perfect; emot_unc, fear of emotional discomfort due to weight gain; phys_unc, fear of physical discomfort due to weight gain; body, fear of disliking how one's body feels due to weight gain; eat_oth, fear of eating in front of others; hi_cal, fear of losing control if one eats high calorie foods; full, fear of gaining weight if one feels full; lose_ctrl, fear of losing control due to weight gain; ctrl, fear of losing control if one cannot control their eating; anx, eating anxiety; eat_unc, eating discomfort; tense, feeling tense around food, food_anx, food anxiety; worry, worry about eating; hard_eat, difficulty eating due to nervousness; near, disliking when food is nearby; avd, avoiding certain foods due to anxiety; patt, food rituals; ord, eating food in a certain order; dont_like, disliking certain foods; no_touch, not touching certain foods due to texture; avd_type, avoiding certain types of food; avd_eat, avoiding eating, rules, eating rules; anx_fat, eating anxiety due to fear of fatness; sick, eating anxiety due to fear of getting sick; stom, disliking eating due to the way one's stomach feels after eating; body_dis, eating anxiety due to fear of body dissatisfaction; anx_other, public eating anxiety; oth_jge, public eating anxiety due to fear of judgment; soc, disliking eating in social situations; worry_w, limiting intake due to weight anxiety; phys_sens, physical discomfort while eating. White nodes represent eating disorder symptom (EDE-Q) items. Grey nodes represent eating disorder fear (EFQ and FOFM) items. Highlighted black nodes denote the most central symptoms [Color figure can be viewed at wileyonlinelibrary.com]

3.2 | Network 2: ED Symptom and ED fear network

3.2.1 | Central symptoms

Network 2 was stable (.75). Symptoms with the highest strength centrality were *a desire to lose weight* (EDE-Q; >100% of all symptoms), *feeling tense around food* (FOFM; >82.61% of symptoms), *disliking eating in social situations* (FOFM; >69.57% of symptoms), *fear of disliking how one's body feels due to weight gain* (EFQ; >66.67% of the other symptoms), and *weight dissatisfaction* (EDE-Q; >72.25% of symptoms; see Figures 3 and 4). Strength centrality and variance were significantly negatively related in Network 2 ($r = -.27, p = .023$).

3.2.2 | Bridge symptoms

Bridge strength was stable (bridge stability = .67). Bridge symptoms with highest centrality were: *restriction* (>100% of other symptoms), *eating*

anxiety due to fear of fatness (> 94.20% of symptoms), and *desiring an empty stomach* (>92.75% other symptoms). Figure 5 shows bridge symptom connections.

3.2.3 | Network comparison tests (undergraduate vs. clinical)

The network comparison tests (NCT) indicated that there were no significant differences in global strength invariance ($p = .16$) or network invariance ($p = .88$). These findings suggest that the overall connections between the symptoms and the structures of the networks were similar. The edge invariance test indicated that 8.07% of all edges were significantly different ($ps < .05$).

3.3 | Multiple regression analyses

Please see Tables 1 and 2 for all multiple regression analyses. In the clinical sample we created a composite variable of *most central fears*,

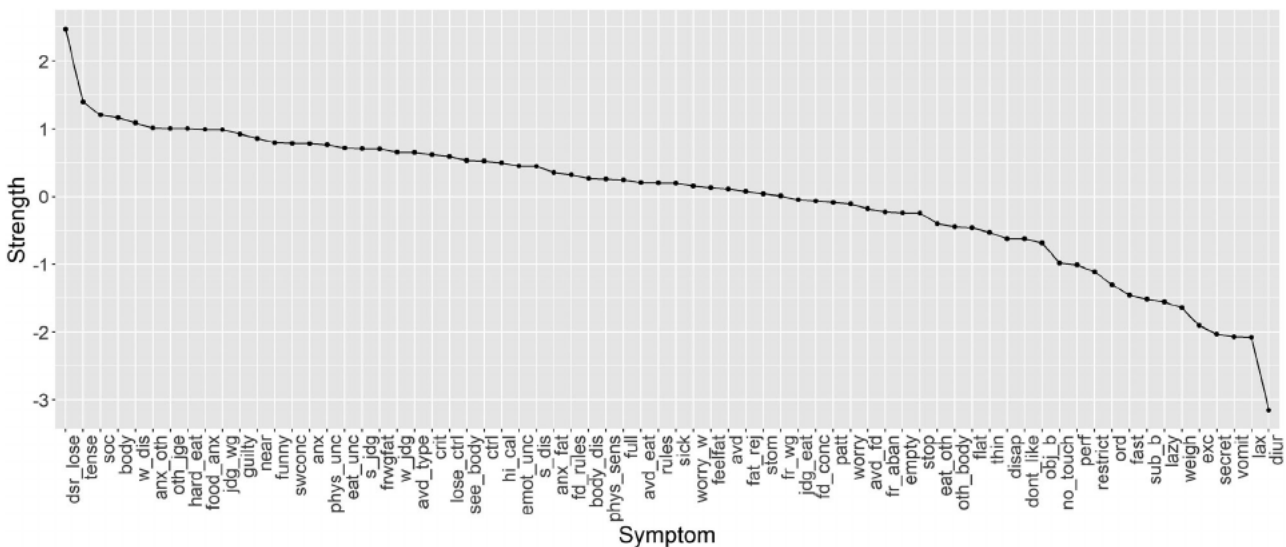


FIGURE 4 Eating Disorder Symptom and Eating Disorder Fear Network (Network 2) Centrality Plot. restrict, restriction; fast, fasting; avd_fd, avoiding foods; fd_rules, food rules fd_conc, difficulty concentrating due to thoughts of food/cal; stop, fear of not being able to stop or resist eating; secret, eating in secret; flat, desiring a flat stomach; empty, desiring an empty stomach; swconc, difficulty concentrating due to thoughts of weight/shape; frwgfat, fear of gaining weight or becoming fat; feel_fat, feeling fat; dsr Lose, desiring weight loss; guilty, feeling guilty because of shape/weight; obj_b, objective binge eating; subj_b, subjective binge eating; vomit, self-induced vomiting; lax, laxative use; diur, diuretic use; exc, excessive exercise; w_jge, judgment based on weight; s_jge, judgment based on shape; weigh, feeling distressed by weekly weighing; w_dis, weight dissatisfaction; s_dis, shape dissatisfaction; thin, desire for thinness; see_body, discomfort seeing one's own body; oth_body, discomfort with others seeing one's own body; fr_wg, fear of gaining weight, fr_aban, fear of abandonment by friends due to fatness; fat_rej, fear of rejection due to fatness; disap, fear of disappointing others due to weight gain, jdg_wg, fear of judgment due to weight gain; funny, fear of being looked at funny due to weight gain; critic, fear of being criticized due to becoming overweight; jdg_eat, fear of being judged based on food choices; lazy, fear of laziness due to overeating; perf, fear of not looking perfect; emot_unc, fear of emotional discomfort due to weight gain; phys_unc, fear of physical discomfort due to weight gain; body, fear of disliking how one's body feels due to weight gain; eat_oth, fear of eating in front of others; hi_cal, fear of losing control if one eats high calorie foods; full, fear of gaining weight if one feels full; lose_ctrl, fear of losing control due to weight gain; ctrl, fear of losing control if one cannot control their eating; anx, eating anxiety; eat_unc, eating discomfort; tense, feeling tense around food, food_anx, food anxiety; worry, worry about eating; hard_eat, difficulty eating due to nervousness; near, disliking when food is nearby; avd, avoiding certain foods due to anxiety; patt, food rituals; ord, eating food in a certain order; dont_like, disliking certain foods; no_touch, not touching certain foods due to texture; avd_type, avoiding certain types of food; avd_eat, avoiding eating, rules, eating rules; anx_fat, eating anxiety due to fear of fatness; sick, eating anxiety due to fear of getting sick; stom, disliking eating due to the way one's stomach feels after eating; body_dis, eating anxiety due to fear of body dissatisfaction; anx_other, public eating anxiety; oth_jge, public eating anxiety due to fear of judgment; soc, disliking eating in social situations; worry_w, limiting intake due to weight anxiety; phys_sens, physical discomfort while eating

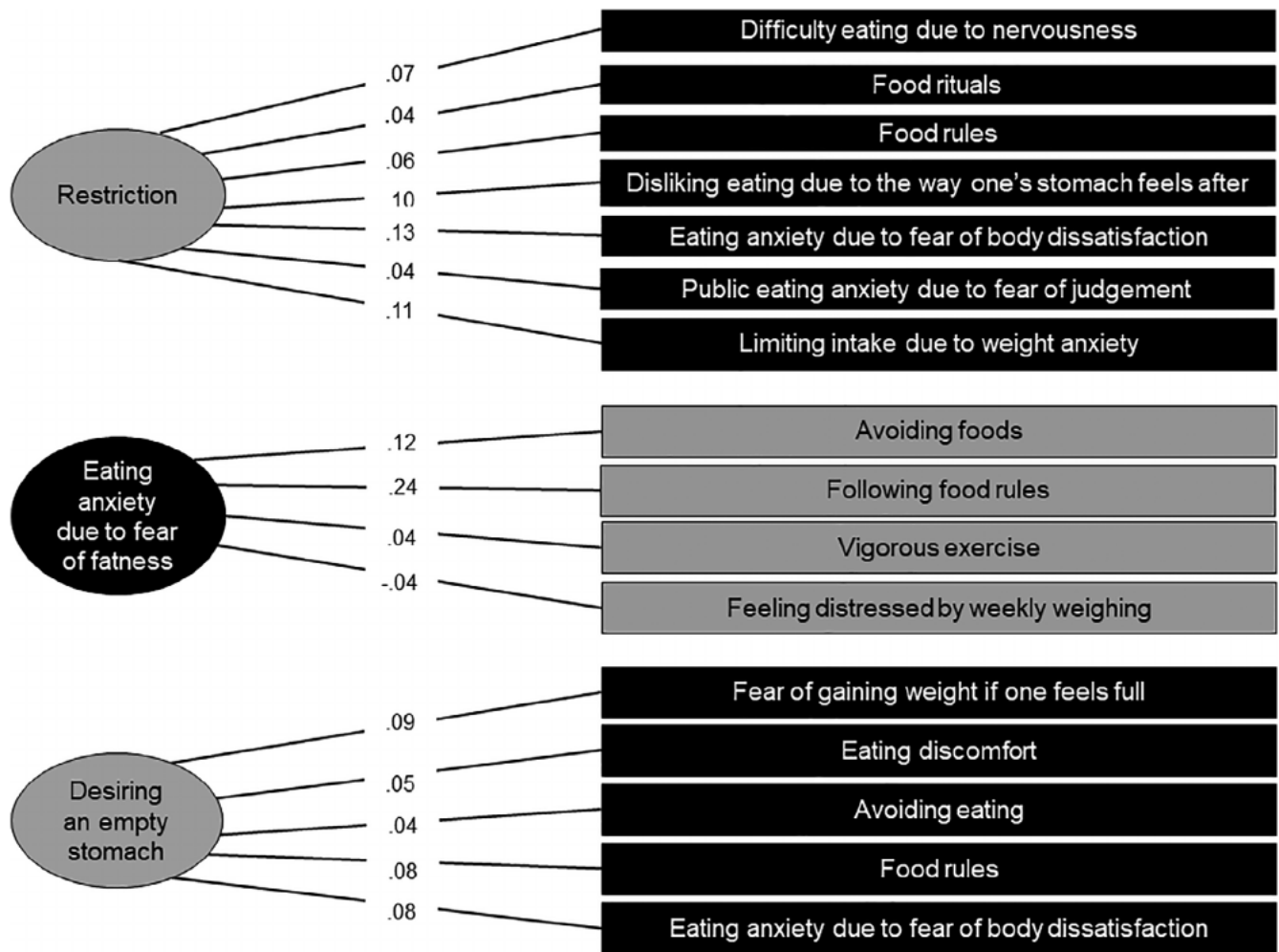


FIGURE 5 Bridge symptoms and connections from Network 2. Eating disorder (EDE-Q) symptoms are represented by black shapes. Eating disorder fears (EFQ and FOFM) are represented by grey shapes. Numbers represent partial correlations among symptoms

including the five most central ED fears (fear of disliking how one's body feels due to weight gain, disliking eating in social situations, feeling tense around food, fear of judgment due to weight gain, and food anxiety) and a composite variable of the five *least central fears* (fear of not looking perfect, eating anxiety due to fear of fatness, eating food in a certain order, and fear of laziness due to overeating, not touching certain foods due to texture). The most central fears significantly predicted excessive-exercise at 2-month follow-up when accounting for excessive-exercise at baseline over and above the least central fears. The most central ED fears did not significantly predict later purging, binge eating, fasting, or overall ED symptoms, nor did the least central symptoms. In post hoc analyses we then tested which specific central fears significantly predicted excessive-exercise. Feeling tense around food, fear of judgment due to weight gain, and food anxiety significantly predicted excessive-exercise at 2-month follow-up when accounting for excessive-exercise at Time 1.

4 | DISCUSSION

EDs are characterized by high levels of fear and anxiety (Levinson & Byrne, 2015; Murray et al., 2018; Swinbourne et al., 2012). However, there is limited knowledge on which fears are most important and how these fears operate alongside other ED-related fears and symptoms. The current study is an initial step in understanding the relations among ED fears and symptoms. We found that our hypotheses were supported, in that fears of weight gain (specifically due to judgment) were most central in an ED-related fear network, and that overvaluation of weight was central in an ED fear and symptom network. Additionally, we found that interoceptive fears and food anxiety were also central to ED fear pathology.

Regarding ED fears, we found that *fear of disliking how one's body feels due to weight gain* was the most central fear. This finding supports a growing body of literature that suggests that interoceptive awareness (IA) may be a primary maintaining factor for EDs

TABLE 1 Multiple regressions among the composite most central eating disorder fears and composite least central eating disorder fears on eating disorder behaviors and EDE-Q global

Predictors	β	Part <i>r</i>	<i>p</i> -value
Regression 1: Central symptoms predicting excessive exercise			
Most central	.14	.12	.043
Least central	.05	.04	.525
T1 exercise	.38	.39	<.001
Regression 2: Central symptoms predicting purging			
Most central	.07	.06	.335
Least central	.02	.02	.820
T1 purging	.60	.60	<.001
Regression 3: Central symptoms predicting objective binge eating			
Most central	-.01	-.01	.889
Least central	.06	.05	.325
T1 objective binge eating	.63	.62	<.001
Regression 4: Central symptoms predicting fasting			
Most central	-.07	-.06	.353
Least central	.04	.04	.545
T1 fasting	.58	.56	<.001
Regression 5: Central symptoms predicting EDE-Q global			
Most central	-.06	-.09	.893
Least central	.09	.02	.816
T1 EDE-Q global	.39	.35	<.001

Note: The most central symptom composite was comprised of fear of disliking how one's body feels due to weight gain, disliking eating in social situations, feeling tense around food, fear of judgment due to weight gain, and food anxiety. The least central symptom composite was comprised of fear of not looking perfect, eating anxiety due to fear of fatness, eating food in a certain order, fear of laziness due to overeating, and not touching food due to texture. The bold values indicate $p < .05$.

TABLE 2 Multiple regressions among the most central eating disorder fears on excessive exercise

Predictors	β	Part <i>r</i>	<i>p</i> -value
Regression 1: Fear of disliking how one's body feels due to weight gain predicting excessive exercise			
Fear of disliking how one's body feels due to weight gain	.08	.08	.175
T1 exercise	.40	.40	<.001
Regression 2: Disliking eating in social situations predicting excessive exercise			
Disliking eating in social situations	.11	.11	.079
T1 exercise	.40	.40	<.001
Regression 3: Feeling tense around food predicting excessive exercise			
Feeling tense around food	.12	.12	.046
T1 exercise	.39	.38	<.001
Regression 4: Fear of judgment due to weight gain predicting excessive exercise			
Fear of judgment due to weight gain	.12	.12	.042
T1 exercise	.42	.42	<.001
Regression 5: Food anxiety predicting excessive exercise			
Food anxiety	.16	.15	.012
T1 exercise	.37	.36	<.001

Note: The bold values indicate $p < .05$.

(Jenkinson, Taylor, & Laws, 2018), including network research that has found IA to be an overall central symptom in inpatients with EDs (Olatunji et al., 2018). In particular, this network suggests that the specific type of interoception that is associated with fear, are feelings in the body associated with weight gain. This finding has implications for treatment, given that most refeeding treatments necessitate weight gain (Garber et al., 2016), and therefore will likely result in heightened bodily sensations related to weight gain. Treatment focused on disrupting connections between such IA and fear may help weaken overall ED fear. One such avenue to target interoceptive fears is imaginal exposure, which is associated with large and significant decreases in fears of physical sensations (Levinson et al., 2020).

One of our primary hypotheses was that fear of weight gain would be a central ED fear. Indeed, we found that *fear of judgment based on weight gain* was one of the most central symptoms. This finding is important because it pinpoints that fear of weight gain and the associated *consequence* of judgment are most central to ED-related fears, rather than only *general* fear of weight gain (which we did not find was central). This finding is consistent with prior research that has theorized that the core fear in EDs is not only fear of weight gain and/or food, but rather the associated consequences that may arise from gaining weight/eating (Levinson et al., 2014; Murray et al., 2016). This study is the first empirical research that has demonstrated that an associated consequence to fear is most central among ED pathology. Furthermore, this research begins to answer the question of *why* fear of weight gain may be perceived as distressing: because of the fear of judgment associated with wgaining weight. These findings have several potential clinical implications, suggesting that interventions targeted specifically at fears of judgment due to weight gain may have the most impact on disrupting ED pathology. Interventions designed to disrupt the association between weight gain and judgment, as well as to violate expectancies of catastrophic

outcomes (e.g., I will be judged and lose my friends) because of judgment on weight are needed. Of course, we should note that these interventions should be approached with care, given the documented literature on weight stigma in Western culture (Brewis, SturtzSreetharan, & Wutich, 2018; Jackson, 2016). This finding also reinforces the harmful nature of weight stigma, such that fearing judgment based on weight may perpetuate ED pathology, and the need for societal wide interventions to minimize judgment based on weight and shape.

Additional central fears that were identified were: disliking eating in social situations and feeling tense and anxious about food. In general, this research suggests that there are potential dynamic relations (pending longitudinal and experimental research) among both food and weight-related fears and is the first to model these relationships concurrently. This research continues to support growing literature showing that both food and weight-related fears are crucial for the maintenance of ED pathology, prediction of ED symptoms, and contributes to clinical outcomes such as relapse (Levinson & Byrne, 2015). Taken together with existing literature, there is growing evidence that food and weight gain-related fears are distinct, yet co-occurring aspects of cognitive pathology. Continued research both on treatment development for and neuro-socio-cultural delineation of how such fears operate within and between individuals is needed.

In terms of bridge symptoms, we identified that *restriction*, *eating anxiety due to fear of fatness*, and *desiring an empty stomach* as the strongest bridge symptoms. In particular, restriction bridged to several symptoms of fear of food. This finding suggests that the pathways between restriction, which is a primary symptom of all EDs (Fairburn, Cooper, & Shafran, 2003), to ED fear is specifically through fear of food. This finding fits with prior literature finding that mealtime anxiety is related to restriction in both individuals with AN (Steinglass et al., 2010) and adolescents (White et al., 2015) and that changes in anxiety throughout the course of food exposure and response prevention is also related to caloric intake among individuals with AN (Steinglass et al., 2012). Future research is needed to more clearly delineate how restriction operates in conjunction with food anxiety, and how to disrupt such pathways, which could potentially help alleviate habitual restrictive behaviors.

Additionally, we found that eating anxiety due to fear of fatness bridged to several ED symptoms, including avoiding food, following food rules, and vigorous exercise. This pathway suggests that these ED symptoms might be used to alleviate such fears (e.g., safety behaviors: pending future longitudinal/experimental research) and adds to the growing literature showing that ED symptoms may serve an anxiety reduction function (Lavender et al., 2013; Levinson et al., 2018). Finally, desiring an empty stomach bridged to interoceptive ED fears and ED behaviors (e.g., fear of gaining weight if one feels full, food rules), related to both weight gain and food. This pathway suggests that there may be complex relations among IA, ED behaviors, and primary ED symptoms (i.e., desire for an empty stomach).

This research also builds on findings showing that NA-identified central symptoms predict clinical outcomes, such as BMI and depression (Brown et al., 2020; Meier et al., 2020; Olatunji et al., 2018). Specifically, we found that a composite of the most central ED fears

predicted excessive-exercise over and above the least central symptoms in a subsample of individuals with an ED. Specifically we found that *feeling tense around food*, *fear of judgment due to weight gain*, and *food anxiety* predicted excessive-exercise. It is possible that individuals may engage in physical exercise to cope with their eating and weight-related fears or concerns. There is a paucity of research on excessive-exercise and this study begins to suggest that there may be specific, longer-term relations among ED fear and excessive-exercise. Additionally, consistent with the idea that intervention on central symptoms might disrupt negative clinical outcomes (Brown et al., 2020; Olatunji et al., 2018), these findings suggest that ED-related fears may contribute to higher excessive-exercise across time. We did not however, find that central symptoms predicted any other outcome, including, purging, binge eating, fasting or overall ED symptoms. Future research is needed to test if central symptoms predict outcomes in larger, well-powered samples.

4.1 | Clinical implications

These findings have potential implications for novel treatment development. Specifically, development of treatments focused on the disruption of (a) the association between fear and interoceptive sensations related to weight gain and (b) between weight gain and judgment are needed. Treatments that violate the expectancy that weight gain will lead to judgment and lasting discomfort in the body may weaken ED pathology. Furthermore, intervention on bridge symptoms focused on fear of food might disrupt connections among ED fears and symptoms. For example, exposures focused on eating anxiety arising because of fear of fatness might alleviate restrictive behaviors. Though we should note these data are all cross-sectional and prospective and treatment research is needed before firm conclusions can be made.

4.2 | Limitations and future research

A limitation of this work is the combination of a clinical and undergraduate sample, which was necessary to ensure adequate power for the number of hypothesized nodes in our models (Epskamp et al., 2017) and was used because of the dimensional nature of ED symptoms and fear and anxiety (Clark & Watson, 2006; Kotov et al., 2017; Wildes & Marcus, 2013). However, we should note we did not find major differences in the structure of either of our models when comparing sample types (clinical vs. undergraduate), suggesting that ED pathology (fears and symptoms) likely functions similarly across groups, which is consistent with dimensional models of ED (Wildes & Marcus, 2013), and lending support for the combination of the two samples. Essentially any differences we found were minor and were attributable to very few differences in connectivity and edge weights among symptoms. Future research is needed to continue to test the replicability and generalizability of these models across sample types. Additional research is also needed to test if ED fears vary by ED diagnosis. Finally, our subsample of individuals with a clinical diagnosis used to test prediction of clinical

outcomes was small, limiting our ability to test for small to moderate effect sizes with high power. Despite this limitation, given that this study is the only research we are aware of investigating the nature and conceptualization of ED fear in a clinical and non-clinical sample, we strongly think despite our small sample for the longitudinal analyses, these analyses are warranted. Furthermore, as with any statistical test, there are limitations inherent to NA, though we used strength centrality, which has the most support for its validity and stability. In this case, utilizing centrality as an index of importance has limitations (e.g., Bringmann et al., 2019) and it is currently unknown if targeting central symptoms in treatment can improve outcomes. While network theory proposes that central symptoms may be important intervention points, there is currently no empirical evidence that supports this claim. Future research is needed to test this idea and primary tenant of network theory. Although Bringmann et al. (2019) suggest that strength centrality is the best current measure of network centrality, the reliability and validity of strength centrality have limits, as is the case with any statistical metric. For example, in Model 2, we found that centrality was correlated with variance, though this has not been found to change the interpretation of results in prior research (e.g., Elliott, Jones, & Schmidt, 2020b). Future research should replicate these findings and measure the reliability and validity of strength centrality, as well as identifying alternative measures of centrality in NA. Additionally, given the high heterogeneity present even within diagnoses, future research should use individual longitudinal network analysis to determine if there is significant heterogeneity within-persons and across time.

5 | CONCLUSIONS

This research begins to answer questions about the specific nature of ED fears, primarily finding that interoceptive-fears, food anxiety, and fears of weight gain because of potential judgment are primary central symptoms of ED-related fears. This research has implications for our conceptualization of ED-related fears, suggesting that associated consequences (i.e., judgment, discomfort in one's body) are a primary component of fear. Future intervention development work is needed to create evidence-based treatments that can accurately disrupt fear associations between weight gain, judgment, and physical discomfort.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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