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Patterns of General- and Eating Disorder-Related Psychopathology in Relation to Weight Change in Treatment-Seeking Children

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by

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Introduction

Approximately 35% of youth in the United States have overweight (OW), and 18.5% of youth have obesity (OB) [1]. Some youth with OW/OB have concomitant psychological problems, including higher rates of general psychopathology (i.e., symptoms of anxiety and depression) [2] and more eating disorder (ED) psychopathology (i.e., ED attitudes and behaviors) [3–5]. Relative to youth with healthy weight, youth with OW/OB are more likely to endorse elevated symptoms of anxiety and depression [6,7], greater shape and weight concerns [8], and greater frequency of loss of control (LOC) eating [9], the hallmark feature of binge eating disorder and bulimia nervosa. Independently, general and ED psychopathology during early and middle adolescence are robust prospective risk factors for weight gain [10–16] and the development of partial- or full-syndrome internalizing disorders [17–19] and EDs [20,21].

Although general and ED psychopathology are theoretically distinct constructs, research suggests that they tend to co-occur in youth with OW/OB [7,9,22–25], and rates of general and ED psychopathology are higher among treatment-seeking samples of youth with OW/OB compared to weight-matched, non-treatment seeking youth [26,27]. Further, general and ED psychopathology share risk factors for excess weight gain (e.g., weight-related teasing, body dissatisfaction) in youth [28,29], which suggests that baseline psychopathology may complicate response to obesity treatment. Despite the postulated link between baseline psychopathology and poorer treatment response, studies in youth have shown mixed findings regarding whether *either* form of psychopathology affects weight change; while some studies suggest a clear link between baseline general or ED psychopathology and poorer treatment response [30,31], other studies do not [32–34]. However, the extent to which concurrent general and ED psychopathology are associated with weight change in the context of treatment has not been examined.

Clarifying the association between patterns of concurrent general and ED psychopathology and treatment response is important in light of data that suggest a compounded risk for negative health sequalae among youth with concurrent forms of psychopathology [35–37]. Cross-sectional studies indicate that anxiety symptoms are related to components of the metabolic syndrome [36] and greater serum leptin production [37] only among youth with LOC eating. Moreover, youth with OB and type 2 diabetes who report clinical levels of LOC eating demonstrate greater shape and weight concerns and depressive symptoms compared to youth who do not exhibit LOC eating [35]. Taken together, these preliminary findings suggest that patterns of concurrent general and ED psychopathology may worsen weight-related outcomes in youth with OW/OB. Characterizing these patterns is crucial in order to identify subtypes of youth who may benefit from tailored treatment approaches.

To extend prior work on the association among general and ED psychopathology and treatment response in youth, this study identified distinct profiles of children with varying patterns of general and ED psychopathology using latent profile analysis (LPA), a data-driven approach that identifies unobserved (i.e., latent) groupings of data based on scores on continuous indicators. Latent profiles were then examined in relation to weight change following FBT. Based on recent data that suggest a compounded negative impact of concurrent psychopathology on weight-related outcomes [35–37], we hypothesized that children with high levels of concurrent general and ED psychopathology would demonstrate less weight change following FBT compared to children with low levels of concurrent psychopathology.

Materials and Methods

Participants

Children aged 7-11y with OW/OB (body mass index [BMI; kg/m^2] ≥85th percentile for age and sex) and at least one parent with OW/OB (BMI ≥25 kg/m^2) were involved in a multi-site, randomized-controlled trial of a weight loss maintenance intervention following 4 months of FBT. The results and details of this trial are reported elsewhere[38]. Participants were recruited through media, advertisements, physician referrals, weight loss clinics, and pediatric clinics around St. Louis, MO and Seattle, WA. Parents and children were excluded for the following reasons: current participation in another weight management program; use of weight/appetite-altering medications; presence of medical or psychiatric conditions. Relevant to the current study, only one child was excluded due to the presence of severe mental illness. The protocol was approved by the Institutional Review Board at Seattle Children's Research Institute and Washington University in St. Louis School of Medicine. Written consent and assent were provided by parents and children, respectively.

Procedures

Of the 241 parent-child dyads assessed at baseline, 172 completed 4 months of FBT and were included in the present analyses. Child weights and heights were assessed at baseline and following FBT (4 months). Demographic variables and measures of depressive symptoms, anxiety symptoms, LOC eating, shape concern, and weight concern were collected at baseline.

Intervention

All families completed 4 months of FBT, which is regarded as the first-line treatment for childhood OB due to sustainable improvements in child and parent weight change [39]. FBT is a multi-component intervention that promotes parent and child weight change through addressing

dietary intake, physical activity, parenting behaviors, behavior modification, and changes to the home environment [40]. Specifically, FBT uses the Traffic Light approach [39] to help families reduce the amount of high caloric/energy-dense foods and replace them with lower calorie/nutrient-enriched foods. Physical activity promotion involves both increasing intensity and duration of activity and reducing sedentary behavior. Parent are taught how to establish healthy routines (e.g., weekly family dinners, weekly family meetings to problem-solve and set goals together), reinforce successful approximations of health behavior change (e.g., praising child, providing external rewards), and model a flexible approach to health behavior change. Parents are also encouraged to make changes to the home environment that reflect what they learn in FBT (e.g., increasing access to healthy foods, reducing opportunities for extensive sedentary behavior).

Measures

Demographics

Parents completed demographic questionnaires at baseline that assessed parent and child race, ethnicity, age, and sex. Parental occupation and education were assessed using the Barratt Simplified Measure of Social Status [41], a proxy for socioeconomic status (SES). A total score ranges from 8 ("Level of School Completed = Less than 7th Grade Education", "Occupation = Day Laborer, Janitor, House Cleaner") to 66 ("Level of School Completed = Graduate Degree", "Occupation = Physician, Attorney, Professor"), with higher numbers indicating more years of education and higher-paying occupations.

Body Composition

Trained research staff measured weight using a calibrated electronic scale and height using a stadiometer at baseline and 4 months. Child percentage OW (%OW; i.e., percentage that the

child's BMI was above the median for age and sex) was calculated using CDC 2000 growth charts [42]. Child %OW was chosen as the primary outcome measure over other measures of body composition due to its sensitivity to weight change among children with higher weight status [43]. This was relevant to the current sample, as 50% of children had severe OB (i.e., BMI ≥120% of the 95th percentile) at baseline [38].

Depressive Symptoms

Child-reported depressive symptoms were assessed with the Short Mood and Feelings Questionnaire (SMFQ) [44]. The SMFQ is a 13-item questionnaire that assesses child depressive symptoms in the past two weeks on a scale from 0 ("Not True") to 2 ("True"). Items are summed to form a total score, with higher scores corresponding to greater depressive symptoms. The SMFQ demonstrates good sensitivity and specificity [44].

Anxiety Symptoms

Child-reported anxiety symptoms were assessed with the Screen for Child Anxiety Related Disorders (SCARED) [45]. The SCARED is a 41-item questionnaire that assesses for the presence of anxiety symptoms that map onto DSM-IV diagnostic criteria for generalized anxiety disorder, social phobia, panic disorder, separation anxiety disorder, and school phobia. Items are rated on a scale from 0 ("Not True or Hardly Ever True") to 2 ("Very True or Often True"). Items are summed to form a total score, with higher scores indicative of greater anxiety symptoms. The SCARED demonstrates good validity and reliability and is sensitive to treatment response [45].

LOC Eating Episodes

The number of child-reported LOC eating episodes in the past three months was assessed using the child version of the Eating Disorder Examination (ChEDE) - Overeating Section [46]. Adapted from the adult EDE, the ChEDE is a semi-structured interview that assesses diagnostic

features of eating disorders. A total score of LOC episodes in the past three months was calculated among children who reported experiencing at least one episode of overeating (subjective or objective) with the presence of LOC. The total score was coded as "0" among children who did not report a LOC eating episode in the past three months. The ChEDE demonstrates excellent reliability in samples of youth with OW/OB [47].

Shape Concern and Weight Concern

Child shape concern and weight concern were assessed using the child-report Youth Eating Disorder Examination Questionnaire (YEDE-Q) [48]. The YEDE-Q is a 39-item youth version of the adult Eating Disorder Examination Questionnaire [49], which assesses the frequency of engaging in ED attitudes and behaviors in the past month. Response options were 0 to 6, with higher numbers indicating greater ED attitudes and behaviors. The measure includes four subscales: Restraint, Eating Concern, Weight Concern, and Shape Concern, which are averaged and analyzed separately or averaged to form a global score. The Shape Concern and Weight Concern subscales were included in the current analysis given the high prevalence of ED attitudes in treatment-seeking samples of youth [8], and based on longitudinal data that suggest the importance of preoccupation with shape and weight as prospective predictors of disordered eating compared to other aspects of body image [50]. The YEDE-Q has good psychometric properties and has been validated in samples of youth with OW/OB [47].

Statistical Analyses

All analyses were conducted using R (version 3.6.2) [51]. Latent profile analysis (LPA) was performed using the Mclust library[52]. General psychopathology variables (i.e., anxiety symptoms, depressive symptoms) and ED psychopathology variables (i.e., shape concern, weight concern, LOC eating) were screened for normality, and were subsequently cube root transformed

to reduce positive skewness and rescaled using min-max normalization (i.e., minimum value = 0, maximum value = 1). This transformation was superior to either a logarithmic or square root transformation as determined by reduction in skewness across the variables. Pearson correlations among general and ED psychopathology variables were conducted to examine the overlap among latent constructs.

LPA identified latent profiles of participants based on baseline general and ED psychopathology indicators. Under the assumption that scores on the continuous measures are generated from unobserved latent profiles, participants are assigned probabilistically as belonging to the distinct profiles. The number of unobserved profiles is evaluated iteratively from 1 to 9 profiles, using Bayesian Information Criterion (BIC) values as a tool to assess model fit [53]. BIC penalizes the number of model parameters in order to prevent overfit [53]. As such, BIC values favor more parsimonious models. Generally, lower BIC values are indicative of better model fit. However, BIC values in the Mclust package are inverted; thus higher BIC values in the current analyses are indicative of better model fit [52]. BIC values were compared to Integrated Completed Likelihood (ICL) values, a secondary index of model fit derived from BIC that adds an additional penalty term based on entropy (i.e., component discrimination) [54]. Similarly, the higher ICL values are markers of better model fit in the Mclust package [55].

After determining the optimal latent profile model, one-way analyses of variance (ANOVAs), for continuous variables, or chi square analyses, for categorical variables, were conducted to examine profile differences in demographics and baseline general and ED psychopathology. Significant omnibus tests were followed by Tukey HSD post-hoc tests (for ANOVAs) or Bonferroni corrections (for chi square analyses). Significance was set at $p \leq .008$ to .01 for Bonferroni-corrected chi square analyses depending on the number of comparisons,

and $p \leq .05$ for all other analyses. Multiple linear regression examined whether profile classification at baseline was associated with %OW following FBT (4 month), controlling for child sex, age, race, ethnicity, household SES, and baseline %OW. All tests were two-tailed.

Results

Participant Characteristics

One hundred seventy-two children completed FBT and were included in the LPA. Participant demographics are included in Table 2.1. Correlations among general and ED psychopathology variables ranged from small to large (Table 2.2.).

Table 2.1. Participant Baseline Demographics

Age	9.4 (1.3), range:7-12
Sex	
Female	106 (61.6%)
Male	66 (38.4%)
Race	
Caucasian	122 (70.9%)
Black	27 (15.7%)
Other/Unknown	23 (13.4%)
Ethnicity	
Non-Hispanic	153 (89.0%)
Hispanic	19 (11.0%)
Household SES	44.0 (10.2), range:10.3-64.4
Baseline Child %OW	64.2 (25.2), range:13.8- 180.1
General Psychopathology	
Anxiety Symptoms	19.36 (14.4), range: 0-75
Depressive Symptoms	5.7 (5.3), range: 0-23
ED Psychopathology	
Shape Concern	1.8 (1.6), range: 0-5.8
Weight Concern	2.0 (1.4), range: 0-6
LOC Eating Episodes	4.2 (11.9), range: 0-90

Note. N=172. Values are mean (SD) or N (%). General and ED psychopathology variables are non-transformed and non-standardized.

Table 2.2. Pearson Correlations among LPA Variables

Measures	**1**	**2**	**3**	**4**	**5**
1. Anxiety Symptoms					
2. Depressive Symptoms	0.68**				
3. LOC Eating Episodes	0.25**	0.26**			
4. Shape Concern	0.47**	0.45**	0.20**		
5. Weight Concern	0.49**	0.45**	0.23**	0.84**	

Note. N=172. *p < .05. **p < .01.

LPA Model Identification

BIC and ICL values across 9 components were compared for model fit. Both BIC and ICL criterion selected a model with an ellipsoidal distribution, variable volume, and equal shape (VEV) and with three components (Figure 1.1. and Figure 1.2.). BIC and ICL model fit indices are described in Table 2.3.

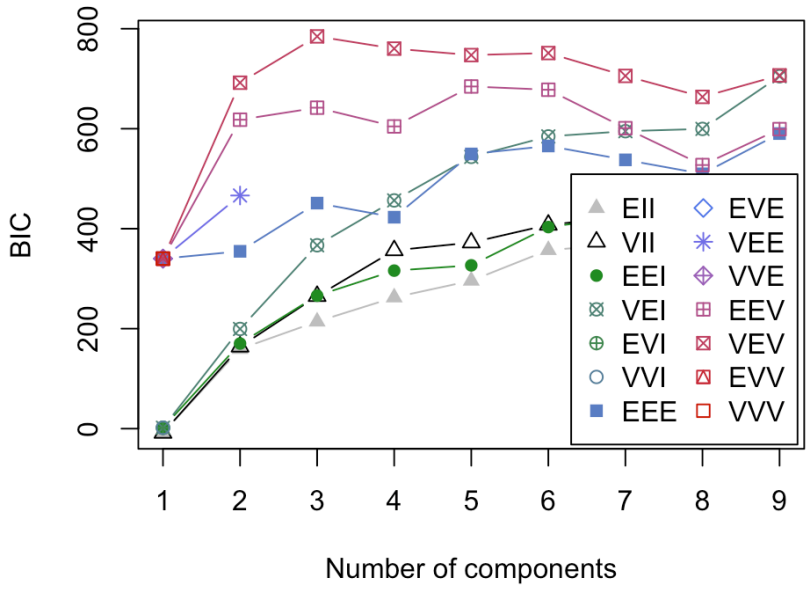

Figure 1.1. Bayesian Information Criterion (BIC) Plots for Model Selection

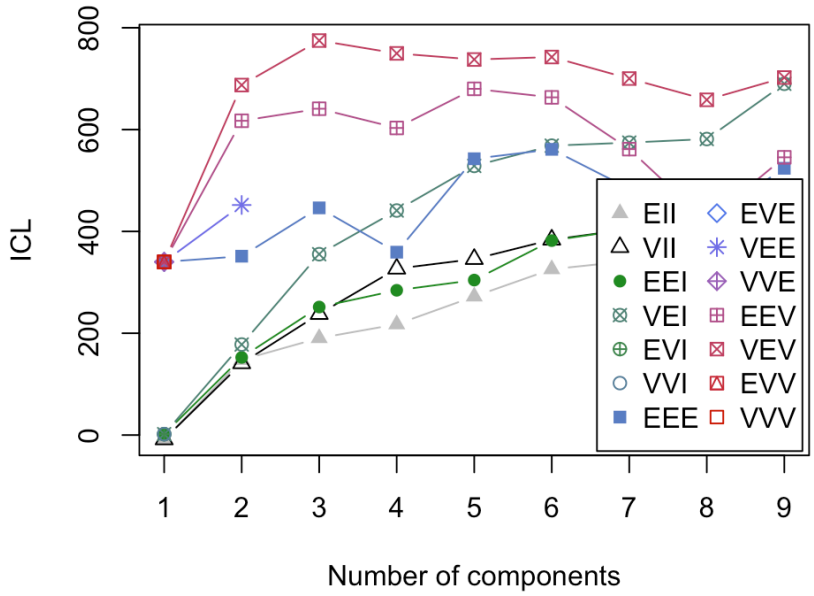

Figure 1.2. Integrated Completed Likelihood (ICL) Criterion for Model Fit Selection

Table 2.3. Model Fit Indices

VEV Components	BIC	ICL
1	340.12	340.12
2	692.03	687.49
3	**784.66**	**774.88**
4	760.23	749.70
5	747.32	737.67
6	751.36	742.55
7	705.64	700.25
8	663.64	658.46
9	706.75	702.24

Note. VEV, ellipsoidal distribution, variable volume, equal shape; BIC, Bayesian Information Criterion; ICL, Integrated Completed Likelihood. The Mclust package considers higher BIC and ICL values to indicate better model fit (bolded values).

Figure 1.3. presents how the normalized mean scores for the 5 general and ED psychopathology variables differed for the 3 profiles. Profile 1 (LOW) comprised 20.3% of the sample (n=35) and were characterized by low levels on all forms of general psychopathology and ED psychopathology (i.e., low depressive and anxiety symptoms, low shape and weight concern,

no LOC eating episodes). Profile 2 (HIGH) comprised 48.8% of the sample (n=84) and demonstrated high general psychopathology (i.e., high depressive and anxiety symptoms) and high ED attitudes (i.e., high shape concern and weight concern) but no LOC eating episodes. Profile 3 (HIGH+LOC) comprised 30.8% of the sample (n=53) and demonstrated high general psychopathology plus high on all forms of psychopathology (i.e., high depressive and anxiety symptoms, high shape and weight concern, and high LOC eating episodes). Posterior probabilities of belonging to profile 1 (LOW) (.97), profile 2 (HIGH) (.97), and profile 3 (HIGH+LOC) (.99) were excellent. Overall discrimination between profiles was excellent (i.e., relative entropy = .93, where values approaching 1 indicate clear profile discrimination). Figure 1.4. presents BIC model uncertainty values, where values closer to 0 indicate less uncertainty that individuals are assigned to a distinct profile.

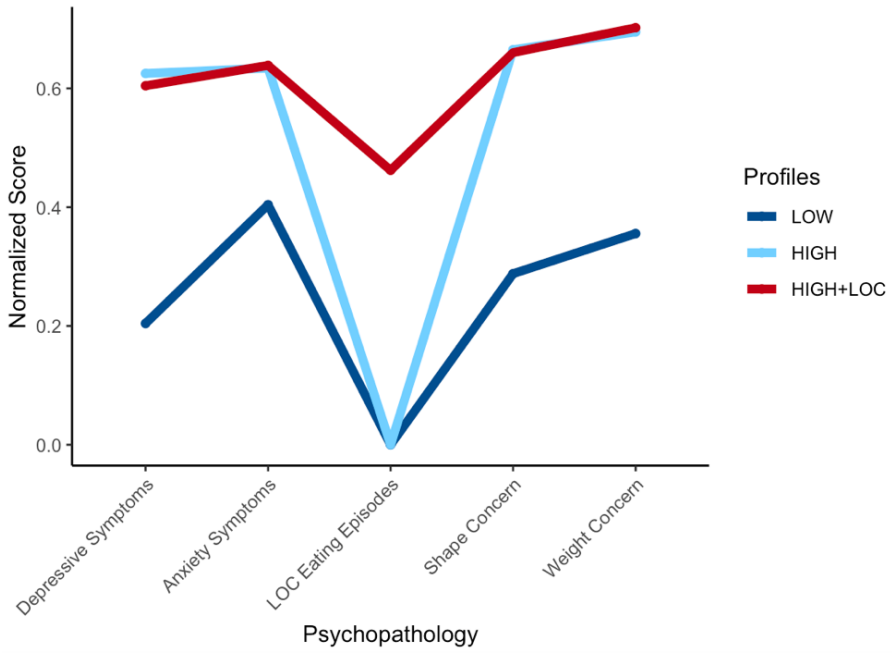

Figure 1.3. Plot of Baseline Latent Classes

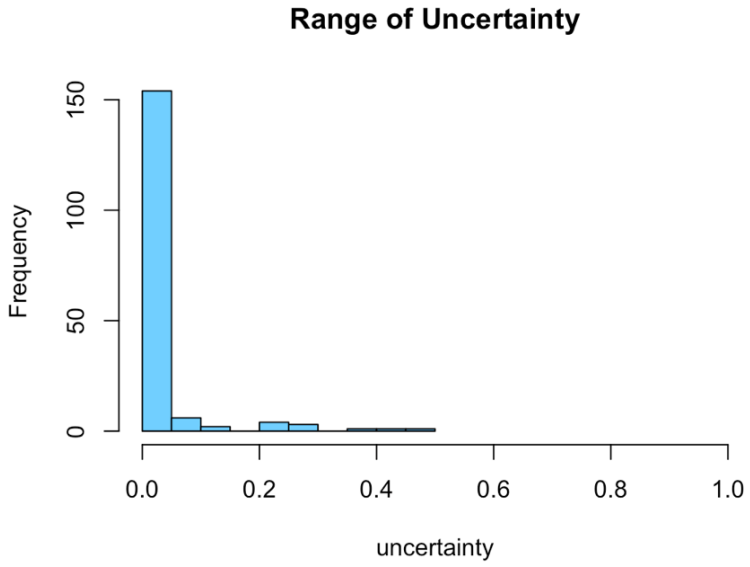

Figure 1.4. Range of Uncertainty of BIC Values

Profile Differences in Demographics and Latent Profile Variables

There were no significant differences in demographics among profiles after adjusting for multiple comparisons (Table 2.4.), although there were significant profile differences in baseline latent variables (Table 2.5.). On measures of general psychopathology (i.e., depressive symptoms and anxiety symptoms) and ED attitudes (i.e., shape concern and weight concern), the LOW profile demonstrated significantly fewer symptoms of depression and anxiety and shape concern and weight concern compared to the HIGH and HIGH+LOC profiles, with no significant differences between HIGH and HIGH+LOC on these measures. Profiles differed on ED behaviors, such that LOW and HIGH profiles demonstrated significantly fewer LOC eating episodes compared to the HIGH+LOC profile.

Table 2.4. Profile Differences in Demographics

Variable	Low Pathology (n=35, LOW)	High Pathology (n=84, HIGH)	High Pathology +LOC (n=53, HIGH+LOC)	Test Statistic (df), *p* value[1], effect size[2]
Age	9.3 (1.3)[a]	9.6 (1.3)[a]	9.3 (1.2)[a]	F(2,169) = 1.63, p = .20, η^2 = .02
Female	22 (62.9%) [a]	44 (52.4%) [a]	40 (75.5%) [a]	$\chi^2(2)$ = 7.35, p = .03, φ = .21
Caucasian	24 (68.6%) [a]	54 (64.3%)[a]	44 (83.0%)[a]	$\chi^2(4)$ = 6.72; p= .53, φ = .14
Non-Hispanic	31 (88.5%)[a]	75 (89.3%)[a]	47 (88.7%)[a]	$\chi^2(2)$ = .02, p = .99, φ = .01
SES	45.0 (8.1)[a]	44.2 (11.1)[a]	42.8 (10.2)[a]	F(2,169) = 1.2, p = .30, η^2 = .01
Baseline Child %OW	63.0 (22.1)[a]	63.1 (24.0)[a]	66.5 (29.1)[a]	F(2,169) = 2.64, p = .71, η^2 = .004

Note. N=172. Values are mean (SD) or N (%). For variables with a significant difference across profiles, superscripts that are not shared among groups indicate significantly different group means. [1] Significance defined as $p \leq .05$ (Tukey-adjusted ANOVAs) or $p \leq .008$ to .01 (Bonferroni-adjusted chi square). [2] Effect sizes are η^2 (ANOVAs) or φ (chi square).

Table 2.5. Baseline General Psychopathology and ED Psychopathology by Latent Profile

Variable	Low Pathology (n=35, LOW)	High Pathology (n=84, HIGH)	High Pathology +LOC (n=53, HIGH+LOC)	Test Statistic (df), *p* value[1], effect size[2]
Depressive Symptoms	0.2 (0.03)[a]	0.6 (0.02)[b]	0.6 (0.03)[b]	F(2,169) = 56.86, p = <.001, η^2 = .40
Anxiety Symptoms	0.4 (0.03)[a]	0.6 (0.02)[b]	0.6 (0.02)[b]	F(2,169) = 30.94, p = <.001, η = .27
Shape Concern	0.3 (0.04)[a]	0.7 (0.02)[b]	0.7 (0.03)[b]	F(2,169) = 39.38, p = <.001, η = .32
Weight Concern	0.4 (0.03)[a]	0.7 (0.02)[b]	0.7 (0.03)[b]	F(2,169) = 44.17, p = <.001, η = .34
LOC Eating Episodes	0.0 (0.01)[a]	0.0 (0.01)[b]	0.5 (0.01)[b]	F(2,169) = 345.47, p = <.001, η = .80

Note. N=172. Values are mean (SD); All values are transformed and standardized. Superscripts that are not shared among groups indicate significantly different group means. [1] Significance defined as $p \leq .05$ (Tukey-adjusted ANOVAs).[2]Effect sizes are η^2.

Relation between Latent Profiles and Post-FBT Weight Change

On average, children regardless of profile achieved clinically significant weight loss (i.e., a 9-unit change in %OW [38]) following FBT. Specifically, the overall sample achieved an average 13.4-unit decrease in %OW from baseline (*M* = 64.2, *SD*= 25.2) to post-FBT (*M* = 50.8, *SD* = 26.1). After controlling for age, sex, race, ethnicity, household SES, and child baseline %OW, latent profiles were not related to %OW following FBT. Summary of adjusted multiple regression analyses are described below (Table 2.6.).

Table 2.6. Summary of Adjusted Multiple Regression Analyses Examining Baseline Latent Profiles as Predictors of Post-FBT Child %OW

Adjusted[1] Change (SE) in %OW during FBT			Between-Profile Comparison in Least-Squares Means (SE); *p* value[2], 95% CI[3]		
LOW	HIGH	HIGH+LOC	LOW vs. HIGH	LOW vs. HIGH+LOC	HIGH vs. HIGH+LOC
-11.8 (1.6)	-12.2 (1.4)	-11.5 (1.7)	0.45 (1.60); *p* = .96; -3.13,4.23	-0.31 (1.74); *p* = .98; -4.43,3.82	-0.76 (1.46); *p* = .86; -4.21,2.70

Note. N=172. R^2 = .91. [1]Adjusted for child age, sex, race, ethnicity, household SES, and baseline %OW. [2]Tukey correction for comparing a family of 3 estimates. [3] CI; 95% confidence intervals.

Discussion

This study used LPA to identify profiles of concurrent general and ED psychopathology in treatment-seeking children with OW/OB. Results supported a three-profile structure: low pathology (LOW) [i.e., low anxiety and depression, low shape concern and weight concern, no LOC]; (HIGH) [i.e., high anxiety and depression, high shape concern and weight concern, no LOC]; and high psychopathology plus high on all forms of ED pathology (HIGH+LOC) [i.e., high anxiety and depression, high shape concern and weight concern, high LOC]. These profiles are in line with prior subgroup analyses that have identified distinct groups of youth with internalizing symptoms and ED attitudes and behaviors, thereby highlighting the salience of

psychological comorbidities across samples of youth with OW/OB [56–59]. Our findings extend prior work by examining how patterns of concurrent psychopathology affect treatment response. In line with some studies [32–34] but in contrast to others [30,60], children on average achieved clinically significant weight loss regardless of baseline psychopathology, which suggests that FBT may be robust across many forms of psychopathology.

The mixed findings on the association between baseline psychopathology and treatment response may be a result of the varying ways in which pediatric weight management programs address, or fail to address, general and ED psychopathology during treatment. Although FBT is not a stand-alone mental health treatment, FBT addresses risk factors for internalizing symptoms and ED symptoms at the parent and child level, thereby increasing the opportunity to mitigate risk for the development and maintenance of child internalizing disorders and eating disorders. Indeed, data show that internalizing symptoms and ED symptoms improve over the course of FBT [61,62]. Additionally, meta-analytic findings indicate that participation in professionally-delivered obesity treatment with a dietary component, such as FBT, is associated with reductions in symptoms of anxiety and depression [63] and ED prevalence, risk, and symptoms [64]. Specifically, FBT teaches parents how to model flexible restraint (e.g., no food is off limits, regular meals) and how to reinforce successful approximations to child health behavior change, which in turn may increase child self-efficacy. Weekly family meetings allow parents to problem solve barriers to health behavior change and provide emotional support [4]. Increases in child self-efficacy and parental support may increase child perceived family functioning, which is a protective factor against childhood OW/OB [65], unhealthy eating behaviors [66], and general and ED psychopathology [67,68]. Thus, supporting child socio-emotional development in the context of obesity treatment may simultaneously target child concurrent psychopathology and excess

weight. Future research should examine mechanisms that underly improvements in general and ED psychopathology over the course of FBT. Further, given the dire need for cost-effective childhood obesity interventions [69], future research should evaluate FBT as an integrated care model for the treatment of OW/OB and concurrent psychological comorbidities.

The current study had several strengths. We used LPA to examine how general and ED psychopathology interact to confer risk for weight change. To our knowledge, this study is the first to use this method to examine the co-occurrence of multiple forms of general and ED psychopathology in relation to weight change among treatment-seeking children with OW/OB. Due to the exploratory nature of LPA, future research should replicate these profile results in other treatment-seeking and non-treatment-seeking samples of children with OW/OB. An additional strength is the use of a large sample of children who reported a wide range of general and ED psychopathology. Given that the present sample was not recruited for presence of a psychiatric diagnosis, nor were the measures selected for their ability to diagnose psychiatric illnesses, our findings may not generalize to treatment-seeking children with full-syndromal symptoms. Nevertheless, our findings demonstrate that concurrent general and ED psychopathology symptoms do not portend differential treatment response. Future research should examine whether children maintain or transition out of these profiles (e.g., symptom improvement) following FBT, and whether such transitions are associated with greater improvements in long-term weight change compared to children who remain symptomatic. Future research should also examine the durability of improvements in weight change following FBT.

Conclusions

Across all profiles, children on average demonstrated clinically significant weight change following FBT, which suggests that FBT may be robust against many forms of child psychopathology. Identification of mechanisms that explain the association between baseline concurrent psychopathology and post-FBT weight change warrant further study. Further, prospective data are needed to examine the durability of treatment effects among these youth with concurrent psychopathology.

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