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An investigation of the joint longitudinal trajectories of low body weight, binge eating, and purging in women with anorexia nervosa and bulimia nervosa

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Abstract

Objectives—To describe the longitudinal course of three core eating disorder symptoms – low body weight, binge eating, and purging – in women with anorexia nervosa (AN) and bulimia nervosa (BN) using a novel statistical approach.

Method—Treatment-seeking women with AN (n=136) or BN (n=110) completed the Eating Disorders Longitudinal Interval Follow-Up Evaluation interview every six months, yielding weekly eating disorder symptom data for a five-year period. Semi-parametric mixture modeling was used to identify longitudinal trajectories for the three core symptoms.

Results—Four individual trajectories were identified for each eating disorder symptom. The number and general shape of the individual trajectories was similar across symptoms, with each model including trajectories depicting stable absence and stable presence of symptoms as well as one or more trajectories depicting the declining presence of symptoms. Unique trajectories were found for low body weight (fluctuating presence) and purging (increasing presence). Conjunction analyses yielded the following joint trajectories: low body weight and binge eating, low body weight and purging, and binge eating and purging.

Conclusions—The course of individual eating disorder symptoms among patients with AN and BN is highly variable. Future research identifying clinical predictors of trajectory membership may inform treatment and nosological research.

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Keywords

anorexia nervosa; bulimia nervosa; symptom trajectories; course; longitudinal

The longitudinal course of eating disorders is often chronic and characterized by substantial symptom fluctuation.¹⁻⁴ Research commonly captures these fluctuations through the use of outcome categories (e.g., remission and relapse) and shifts in diagnostic labels.^{5,6} Crossover data suggest that 20-50% of individuals with an initial diagnosis of anorexia nervosa (AN) develop bulimia nervosa (BN) over time^{4, 7-9} and the rate of crossover between anorexia nervosa subtypes appears to be even higher.^{8, 10-12} Although individual symptom fluctuations drive these outcomes and diagnostic changes over time, few studies have examined the course of the individual eating disorder symptoms and none has reported on patterns of convergence and divergence in these symptoms over time.

Empirical methods of classification, including latent class analysis and latent profile analysis, have been used to identify eating disorder types in cross-sectional research. The results from these studies suggest mixed support for the current diagnostic structure in the DSM-IV,¹³ and expanded our understanding of these classifications by examining potentially useful correlates of membership in the identified classes.¹⁴⁻¹⁹ Similar to these methods of empirically-deriving groups in cross-sectional research are methods that identify patterns of change in longitudinal research. These methods, known as longitudinal latent structure analyses, have only recently been applied to the study of eating disorders. Crosby and colleagues²⁰ used such an approach to identify daily patterns of negative affect in a sample of women with bulimia nervosa. They identified nine unique patterns of daily negative affect and found that two of these patterns, stable high negative affect and increasing negative affect, were specifically associated with higher rates of binge eating and purging during that day. In another study, Cain, Epler, Steinley, and Sher²¹ identified patterns of change between different classes of eating-related psychopathology in a 4-year study of eating, weight, and shape concerns in female undergraduates. They found that the majority of individuals did not change class membership over time, and among those who did change, the shifts were typically to a less severe class. These studies demonstrate the ability of longitudinal latent structure analyses to provide unique information about symptom course.

The purpose of the current investigation was to utilize a novel longitudinal latent structure analysis, which has not previously been applied to the study of eating disorders, to examine the longitudinal course of three hallmark eating disorder symptoms: low body weight, binge eating, and purging in women with eating disorders during 5 years of follow-up. We aimed to: (1) identify longitudinal course trajectories for each of these symptoms and (2) examine relationships among these symptom trajectories over time. We used data from the Massachusetts General Hospital (MGH) Longitudinal Study of Anorexia and Bulimia Nervosa, which prospectively followed a treatment-seeking sample of women with initial diagnoses of AN or BN. This unique dataset was selected due to the availability of prospective weekly longitudinal data for the three eating disorder symptoms of interest in a well-characterized clinical sample.

Method

Participants and Procedure

The sample comprised 246 women who sought treatment for DSM-III-R²² AN or BN at MGH and other treatment centers in the Boston area between 1987 and 1991. Diagnoses were reassigned upon publication of the DSM-IV,¹³ resulting in 51 women with AN, restricting type (ANr), 85 women with AN, binge eating-purging type (ANbp), and 110 women with BN purging type (BNp). Participants' mean age at intake was 24.8 (6.7) years. The mean duration of illness was 6.7 (6.1) years and the average age at onset of eating disorder was 18.1 (5.6) years. The participants were primarily Caucasian and middle to upper middle class.

Trained interviewers administered the Eating Disorders Longitudinal Interval Follow-Up Evaluation, a modified version of the Longitudinal Interval Follow-Up²³ every 6 months. These assessments yielded weekly data on the presence of various eating disorder symptoms including low body weight (i.e., $\leq 85\%$ ideal body weight), objective binge eating, and purging (i.e., laxative use, self-induced vomiting, and diuretic use). Data for each symptom were dichotomously coded and indicated the presence or absence of a particular symptom each week. Binge eating and purging were coded as present for the week if the participants reported engaging in the behavior at any frequency, while low body weight was coded as present if the participant was $\leq 85\%$ ideal body weight. The study sample and methodology have been described in greater detail elsewhere.^{24, 25}

Women were followed for a median of 9 years and $>90\%$ of these women were followed for 5 consecutive years. Thus, a 5-year follow-up interval was used in the current analyses to maximize the available data and to avoid the widening confidence intervals that exist beyond 5 years due to attrition. Within the 5-year follow-up interval, there was approximately 4% missing data. Participants with missing data remained in the sample for data analysis. These missing values were treated as data missing completely at random in the statistical analyses.²⁶

Statistical Analyses

The primary analyses were conducted with dichotomously coded weekly data and proceeded in three steps. First, semi-parametric group mixture modeling^{27,28} was used to identify individual trajectory models for the three symptoms: low body weight, binge eating, and purging. All participants ($N=246$) were included to estimate the models for each of the symptoms. Because data were dichotomously coded, the binary logit distribution was used to model the trajectories. For each distinct trajectory, the model defined the trajectory shape (i.e., linear, quadratic, or cubic) and the proportion of the participants assigned to the trajectory. Model selection was based on several criteria: model parsimony, knowledge of the area of study, and the Bayesian Information Criterion (BIC), calculated as $-2\log(L) + \log(n)*k$, where L is the model's maximized likelihood, n is the sample size, and k is the number of model parameters.²⁶

Second, the separate models identified in the first step were used to guide the estimation of three joint models: (1) low body weight and binge eating, (2) low body weight and purging,

and (3) binge eating and purging. The joint probabilities reflect the proportion of participants estimated to simultaneously belong to specific trajectories from the two individual models (e.g., the probability of being assigned to a given low weight trajectory *and* a given binge eating trajectory). These joint analyses allow for an examination of how multiple symptoms fluctuate and interact over time, by investigating empirically derived eating disorder syndromes as opposed to traditional diagnostic classes.

Results

Individual Trajectory Models

Fit indices for models including one to six trajectories for low body weight, binge eating, and purging are shown in Table 1. Fit indices were calculated using SAS mixturefit.²⁹ Because the fit indices continued to improve with the addition of more trajectories, knowledge of the area of study and model parsimony guided model selection, as suggested by Nagin.²⁶ The best model for each symptom was selected by comparing models to one another with a bias toward parsimony (i.e., retaining the model with fewer trajectories). A model with more trajectories was selected only if the additional trajectory conveyed unique information about the data; if the additional trajectory was composed of elements from already existing trajectories or split a trajectory into high and low groups, the more parsimonious model was retained. Final decisions were made by consensus of the authors, and resulted in four trajectories for each of the three symptoms (see Figures 1-3).

For low body weight, approximately one half (56.1%) of participants were assigned to the “non-low weight” trajectory, and approximately one quarter (24.4%) followed the “persistent low weight” trajectory. A smaller proportion of individuals followed “gaining from low weight” (11.8%) and “fluctuating weight” (7.7%) trajectories. While the majority of participants were assigned to one of the two stable trajectories, approximately one-fifth of the sample followed a trajectory characterized by weight change. This subset may include individuals initially diagnosed with AN who experienced a cross-over to BN or eating disorder not otherwise specified, as well as those who experienced weight gain during a period of remission.

For binge eating, approximately one third (34.9%) of participants followed the “persistent binge eating” trajectory. The second largest group (27.4%) followed the “non-binge eating” trajectory, while the remainder of the sample was divided between the “early decreasing binge” trajectory (17.8%) and the “late decreasing binge” trajectory (19.9%). Individuals in the “early decreasing binge” trajectory reached levels of binge eating similar to those of individuals in the “non-binge eating” trajectory by approximately 3 years into the study. In contrast, individuals following the “late decreasing binge” trajectory did not begin to exhibit decreases in binge eating until approximately 2 years into the study and remained at a higher probability of binge eating at the five-year mark.

For purging, approximately one third (36.2%) of participants followed the “non-purging” trajectory, and more than one quarter (28.9%) followed the “persistent purging” trajectory. Just over one-fifth (20.7%) of participants were assigned to the “steady decreasing purging” trajectory, while the remainder (14.2%) followed the “increasing purging” trajectory. The

likelihood of engaging in purging decreased in a linear fashion among individuals in the “steady decreasing” category, whose likelihood of purging at the five-year mark was near zero. Participants who followed the “increasing purging” trajectory exhibited an increasing probability of purging, reaching levels similar to those of the “persistent purging” trajectory at the five-year mark.

Low Body Weight and Binge Eating Joint Trajectory Model

Table 2 presents the results for the low body weight and binge eating joint trajectory analysis. The upper portion of Table 2 shows the joint probabilities of membership in the low body weight and binge eating trajectories, which sum to 1. The four most common joint trajectories, which included nearly two thirds of the total sample (61.6%), were: (1) “non-low weight” and “persistent binge eating” (23.6%); (2) “non-low weight” and “late decreasing binge eating” (14.6%); (3) “persistent low weight” and “non-binge eating” (12.5%); and (4) “non-low weight” and “early decreasing binge eating” (10.9%). Each of the remaining joint trajectories individually accounted for less than 8% of the total sample.

The lower portion of Table 2 presents the joint probabilities by intake diagnosis (i.e., the probability of being assigned to any certain joint trajectory based on intake diagnosis). For instance, 45.1% of individuals with ANr, 9.4% of individuals with ANbp, and no individuals with BN were assigned to the joint trajectory of “persistent low weight” and “non-binge eating.”

Low Body Weight and Purging Joint Trajectory Model

Table 3 presents the results for the low body weight and purging joint trajectory analysis and can be interpreted similarly to Table 2, as outlined above. The joint probabilities follow a similar pattern to those in the low body weight and binge eating model, with the four most common joint trajectories accounting for 60.2% of the total sample. These included: (1) “non-low weight” and “persistent purging” (17.1%); (2) “non-low weight” and “non-purging” (16.3%); (3) “non-low weight” and “steady decreasing purging” (16.2%); and (4) “persistent low weight” and “non-purging” (10.6%). Each of the remaining joint trajectories individually accounted for less than 8% of the total sample.

The pattern of joint trajectory membership across diagnoses was similar to that found in the low body weight and binge eating model, with 41.2% of individuals diagnosed with ANr assigned to the joint trajectory of “persistent low weight” and “non-purging,” only 5.9% of individuals with ANbp assigned to this joint trajectory, and no individuals with BN following this joint trajectory.

Binge Eating and Purging Joint Trajectory Model

Table 4 presents the results for the purging and binge eating joint trajectory analysis. The two most common joint trajectories, “non-binge eating” and “non-purging,” and “persistent binge eating” and “persistent purging,” accounted for nearly half of the total sample, while the remainder of the sample was widely dispersed across the other joint trajectories.

The pattern of joint trajectory membership revealed that no individuals with ANr, 41.2% of individuals with ANbp, and 27.3% of individuals with BNp were assigned to the joint trajectory of “persistent purging” and “persistent binge eating.”

Discussion

To our knowledge, this study is the first to examine the individual course of multiple eating disorder symptoms. Four trajectories were identified for each of the three symptoms: low body weight (non-low weight, fluctuating weight, gaining from low weight, and persistent low weight), binge eating (non-binge eating, early decreasing binge eating, late decreasing binge eating, and persistent binge eating), and purging (non-purging, increasing purging, steady decreasing purging, and persistent purging). The number and general shape of the individual trajectories was mostly similar across symptoms, with each model including trajectories depicting stable absence and stable presence of symptoms as well as one or more trajectories depicting the declining presence of symptoms. However, unique trajectories were identified for two symptoms: “fluctuating weight” and “increasing purging.” For these symptoms, the unique trajectories were the most infrequent.

Thus the results of this study highlight both the stability of eating disorder symptoms in some cases, and in others, their tendency to fluctuate. For instance, most individuals who followed the trajectory of “persistent low weight” also followed “non-binge eating” and “non-purging” trajectories, a pattern indicative of chronic low weight in the absence of regular binge eating and purging that resembles the syndrome of ANr. In fact, over 40% of individuals with an intake diagnosis of ANr followed each of these two joint trajectories. Conversely, most individuals who followed the trajectory of “fluctuating weight” followed trajectories of decreasing or persistent binge eating and purging, a pattern that likely characterizes individuals moving between the diagnostic categories of ANbp and BNp and perhaps even ANr.

This type of movement among eating disorder diagnoses has become known as diagnostic crossover, as reflected in changes in body weight, binge eating, and purging. For example, when an individual with ANbp who regularly engages in both binge eating and purging gains enough weight to rise above a given threshold, her diagnosis changes to BNp. Retrospective and prospective studies with assessment periods ranging from months to years have revealed that a substantial percentage of individuals initially diagnosed with AN later develop BN, while crossover from BN to AN appears to be comparatively rare.³⁰⁻³² Eddy and colleagues,³³ using this same dataset, found that 34% of individuals who initially presented with AN crossed over to BN at some point during a 7-year follow-up period, and nearly half of these individuals later crossed back to AN. Crossover from BN to AN was less common, with only 14% following this course. The results of the present study build on the existing course and crossover literature by empirically deriving trajectories for the specific symptoms that are responsible for changes in eating disorder diagnosis over time. Thus, similar to empirical methods of classifying disorders (e.g., latent class and latent profile analyses), this paper used an empirical approach to classify the course of three of the major eating disorder symptoms.

Examining the unique trajectories of “increasing purging” and “fluctuating weight” may be particularly useful in illustrating the phenomenon of diagnostic crossover, as well as the reality of symptom fluctuation and periodic remission. For instance, the “increasing purging” trajectory may include both individuals whose purging behaviors accelerated over time, as well as those who exhibited purging behaviors at baseline and later experienced a period of remission. Similarly, as noted previously, those assigned to the “fluctuating weight” trajectory likely included those moving between diagnostic categories, as well as individuals who exhibited periods of normal weight and subclinical symptomatology.

There are several clinical implications of the current findings. If future research could identify clinical predictors of individual or joint trajectory membership, interventions might be developed or tailored to assist patients with eating disorders to move toward a trajectory of decreasing symptomatology. For example, learning what differentiates those patients whose symptoms remit early versus those with more persistent patterns might result in the developing novel treatment strategies and greater attention to individuals whose symptom course is persistent and perhaps treatment-refractory. By utilizing the joint models, we may be able to identify factors that predict specific symptom configurations that may seem counter-intuitive (e.g., increasing purging and decreasing binge eating). Bohon³⁴ and colleagues recently examined factors predicting the stability of bulimia symptoms, which may influence the focus of treatment. Fairburn et al.³⁵ developed the most recent version of cognitive behavioral therapy to be able to be adapted for specific symptom sets, and treatment efforts such as these might be used in conjunction with the identification of symptom trajectories. For instance, we may find that certain joint trajectories are characterized by elevated levels of affect dysregulation, while others are associated with interpersonal difficulties. Further, identifying clinical predictors of symptom trajectories could inform nosological research aimed at clarifying boundaries within the eating disorders (e.g., between ANr and ANbp).

Although this study applied a novel empirical approach to contribute to the small existing literature on the longitudinal course of eating disorder symptoms, the findings should be interpreted in light of certain limitations. One, the sample was composed of treatment-seeking women who received a wide range of treatments throughout the course of the study³⁶ and the impact of treatment on the course of the various eating disorder symptoms was not examined as it was beyond the scope of this study. Future studies should attempt to determine if the course of eating disorders in a non-treatment seeking sample is characterized by similar trajectories. Two, the study design required that participants be diagnosed with AN or BN, therefore the symptom trajectories identified may not generalize to individuals with subthreshold presentations or EDNOS, including binge eating disorder and purging disorder. Future studies should attempt to replicate the current trajectories in samples including individuals with a broader array of eating disorder symptom patterns. Although the overall sample was relatively large, the number of individuals assigned to many of the joint trajectories was small.

Future research using this statistical technique could be designed to replicate and build on these preliminary findings. Such analyses could be applied to other large longitudinal datasets that include both clinical and nonclinical samples of individuals with eating

disorders to address external validity. Determination of predictors of trajectory membership might shed light on potential targets for intervention and also may inform classification research. Identifying dispositional and contextual predictors of membership may lead to improved treatment strategies aimed at deflecting an individual's trajectory from one of long-term suffering to one of improvement.

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Figure 1.
Longitudinal trajectories for low body weight.

Figure 2.
Longitudinal trajectories for binge eating.

Figure 3.
Longitudinal trajectories for purging.

Table 1

Indices of Model Fit for Individual Trajectory Models

Fit Indices	Purging Models (number of trajectory groups)					
	1	2	3	4	5	6
Entropy	--	0.999	0.998	0.998	0.999	0.997
AIC	83135.92	48930.78	42383.84	37835.54	34777.38	32997.22
BIC	83153.45	48962.33	42432.92	37898.64	34865.01	33095.37
cAIC	83158.45	48971.33	42446.92	37916.64	34890.01	33123.37
ssBIC	83137.60	48933.80	42388.54	37841.58	34785.76	33006.61
CLC	83125.92	48912.97	42356.83	37800.57	34728.50	32943.97
ICL-BIC	83153.45	48962.52	42433.90	37899.67	34866.13	33098.12
Fit Indices	Binge Eating Models (number of trajectory groups)					
	1	2	3	4	5	6
Entropy	--	1.000	0.998	0.998	0.996	0.996
AIC	84068.88	49759.76	43140.62	40331.68	37726.56	36280.74
BIC	84086.41	49787.80	43186.19	40394.78	37814.19	36385.90
cAIC	84091.41	49795.80	43199.19	40412.78	37839.19	36415.90
ssBIC	84070.56	49762.44	43144.98	40337.72	37734.94	36290.80
CLC	84058.88	49743.83	43115.55	40296.85	37679.35	36224.24
ICL-BIC	84086.41	49787.87	43187.12	40395.95	37816.98	36389.40
Fit Indices	Low Weight Models (number of trajectory groups)					
	1	2	3	4	5	6
Entropy	--	1.000	0.998	0.994	0.994	0.998
AIC	76402.92	31983.70	23874.46	20090.70	17574.20	16656.62
BIC	76413.44	32015.25	23916.52	20150.29	17661.83	16761.78
cAIC	76416.44	32024.25	23928.52	20167.29	17686.83	16791.78
ssBIC	76403.93	31986.72	23878.48	20096.40	17582.58	16666.68
CLC	76396.92	31965.70	23851.47	20060.71	17528.91	16598.65
ICL-BIC	76413.44	32015.25	23917.53	20154.30	17666.55	16763.81

Note: AIC = Akaike Information Criterion; BIC = Bayesian Information Criterion; cAIC = Consistent AIC; ssBIC = Sample size-adjusted BIC; CLC = Classification Likelihood Information Criterion; ICL-BIC = Integrated Classification Likelihood-BIC.

Table 2

Probability Estimates for Low Body Weight and Binge Eating Trajectories

Binge Eating	Low Body Weight			
	Non-low weight	Fluctuating weight	Gaining from low weight	Persistent low weight
Joint Probabilities of Binge Eating and Low Body Weight				
Non-binge eating	.070	.016	.063	.125
Early decreasing binge	.109	.028	.016	.024
Late decreasing binge	.146	.008	.023	.026
Persistent binge eating	.236	.024	.017	.069
Joint Probabilities of Low Body Weight and Binge Eating by Intake Diagnosis ^a				
Non-binge eating	.059/.035/.100	.059/ -- /.009	.216/.047/ --	.451/.094/ --
Early decreasing binge	.020/.082/.173	.020/.024/.036	.020/.035/ --	.020/.047/.009
Late decreasing binge	.039/.071/.255	-- /.012/.009	.039/.035/.009	.039/.047/ --
Persistent binge eating	-- /.188/.382	-- /.047/.018	.020/.035/ --	-- /.200/ --

^a Within each cell, the first value represents the proportion of individuals with ANr assigned to the joint trajectory, the second value represents the proportion of individuals with ANbp assigned to the joint trajectory, and the third value represents the proportion of individuals with BNp assigned to the joint trajectory. Dashes indicate that no individuals from that diagnostic group were members of that joint trajectory.

Table 3

Probability Estimates for Low Body Weight and Purging Trajectories

Purging	Low Body Weight			
	Non-low weight	Fluctuating weight	Gaining from low weight	Persistent low weight
Joint Probabilities of Purging and Low Body Weight				
Non-purging	.163	.024	.069	.106
Increasing purging	.065	.008	.016	.053
Steady decreasing purging	.162	.016	.016	.012
Persistent purging	.171	.028	.017	.073
Joint Probabilities of Low Body Weight and Purging by Intake Diagnosis ^a				
Non-purging	.078/.071/.273	.078/ -- /.018	.196/.082/ --	.412/.059/ --
Increasing purging	.039/.035/.100	-- /.012/.009	.059/.012/ --	.098/.082/.009
Steady decreasing purging	-- /.129/.264	-- /.024/.018	.020/.024/.009	-- /.035/ --
Persistent purging	-- /.141/.273	-- /.047/.027	.020/.035/ --	-- /.212/ --

^aWithin each cell, the first value represents the proportion of individuals with ANr assigned to the joint trajectory, the second value represents the proportion of individuals with ANbp assigned to the joint trajectory, and the third value represents the proportion of individuals with BNp assigned to the joint trajectory. Dashes indicate that no individuals from that diagnostic group were members of that joint trajectory.

Table 4

Probability Estimates for Purging and Binge Eating Trajectories

Purging	Binge Eating			
	Non-binge eating	Early decreasing binge	Late decreasing binge	Persistent binge eating
Joint Probabilities of Purging and Binge Eating				
Non-purging	.220	.061	.073	.008
Increasing purging	.045	.016	.041	.041
Steady decreasing purging	.008	.094	.069	.035
Persistent purging	.008	--	.016	.266
Joint Probabilities of Binge Eating and Purging by Intake Diagnosis ^a				
Non-purging	.647/.118/.100	.039/.047/.082	.059/.047/.100	.020/--/.009
Increasing purging	.157/.024/.009	--/.024/.018	.039/.059/.027	--/.035/.064
Steady decreasing purging	--/.024/--	--/.118/.118	.020/.047/.109	--/.024/.064
Persistent purging	.020/.012/--	--/--/--	--/.012/.027	--/.412/.273

^a Within each cell, the first value represents the proportion of individuals with ANr assigned to the joint trajectory, the second value represents the proportion of individuals with ANbp assigned to the joint trajectory, and the third value represents the proportion of individuals with BNp assigned to the joint trajectory. Dashes indicate that no individuals from that diagnostic group were members of that joint trajectory.