Cluster Analysis of Eating Disorder Behaviors using EMA Technology: A Secondary Analysis of Randomized Clinical Trial Data

by

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Abstract

Eating disorders are a dangerous form of mental illness and very little is understood regarding individual behavioral patterns. The goal of current study is to determine if meaningful eating disorder behavioral patterns can be identified within and among eating disorder (ED) diagnostic categories by using a cluster analytic approach. This study is a secondary analysis of data collected as part of a randomized clinical trial of an identity focused cognitive-behavioral psychotherapy designed to promote recovery and health women with AN and BN. Sixty-five women diagnosed with either threshold or subthreshold anorexia nervosa (AN) or bulimia nervosa (BN) completed 21 days event- and signal-triggered EMA methodology to prospectively measure eight ED behaviors. Bivariate correlations and cluster analyses were used to explore the natural groupings of 11 eating disorder variables. The average number of behavioral episodes (M = 36.40) and percentage of days with no recorded behavior (M = 16.62). The most frequent behaviors included restricting (M = 35.76%), vomiting (M = 28.71%), and bingeing (M = 14.63%). Significant correlations were found between a few important variables, including restricting and vomiting (r = -.583, p < .01) and other structural behaviors representative of daily behavioral patterning. This study supported the notion that by examining a wide spectrum of eating disorder behaviors, natural groupings of eating disorder individuals can be found through cluster analysis. The goal of this study was to add depth to our knowledge regarding daily behavioral engagements of women diagnosed with an ED and in doing so holds potentially improve approaches to assessment and treatment.

Cluster Analysis of Eating Disorder Behaviors using EMA Technology: A Secondary Analysis of Randomized Clinical Trial Data

Each year, over five-million Americans are diagnosed with an eating disorder (Becker, Grinspoon, Klibanski, & Herzog, 1999). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IVTR; 2000), eating disorders (ED) include three diagnostic categories: anorexia nervosa (AN), bulimia nervosa (BN), and eating disorder not otherwise specified (EDNOS) and these three diagnostic categories are defined by specific symptom profiles that are used to determine the presence or absence of each eating disorder. However, current research on eating disorders is beginning to question the homogeneity of individuals within these diagnostic categories (Wonderlich, Joiner, Keel, Williamson, & Crosby, 2007). Although clear objective boundaries are inherent in the DSM system, there is emerging evidence that important variability within a diagnosis can be masked by the diagnosis itself. For example, research has shown that individuals with the same diagnosis engage in multiple different purging and non-purging behaviors (Clinton et al., 2004), thus making it difficult to identify and measure individual behavioral change. The goal of current study is to determine if meaningful eating disorder behavioral patterns can be identified within and among the ED diagnoses categories by using a cluster analytic approach.

Recent studies provide preliminary evidence to suggest behavioral patterns within the eating disorder diagnoses. As suggested by Wonderlich, et al. (2007), an exploration and expansion of behaviors constituting the eating disorder is necessary. Studies have shown that eating disordered behaviors may be entrained to days of the week and times of the day. For example, Smyth and colleagues (2004) found day of week effects on eating disorder behaviors, in that there was a significant day of week effect on vomiting and a marginally significant effect

on bingeing. Both events occurred with greatest frequency on Sunday, even as compared with Friday and Saturday. Similarly, other studies have examined correlations between the behaviors themselves. Reba and colleagues (2005) found that laxative use negatively predicted other forms of purging behaviors including diuretic use and vomiting; Reba-Harrelson and colleagues (2008) found that diet pill use positively predicted vomiting, and similarly, that diet pill use positively predicted other types of purging; and Shroff and colleagues (2006) found a positive correlation between excessive exercise and the diagnosis of anorexia nervosa-purging type.

Important behavioral correlations can be overlooked by current diagnostic categories. The diagnosis of BN, which is characterized by alternating episodes of binge eating and compensatory behavior to avoid weight gain, is not specific to the type of compensatory behaviors used. Similarly, the diagnosis of AN is based on physical outcomes including amenorrhea and low BMI, but is mute on the specific behaviors that lead to the physical outcomes. Thus, from a diagnostic perspective, a single diagnosis may encompass several distinct behavioral patterns and, conversely, behavioral patterns may exist across diagnoses. By looking at the prevalence and temporal occurrence of eating disorder variables, this study will broaden the spectrum of knowledge regarding daily behavioral engagements of women diagnosed with an ED and in doing so holds potential for improving approaches to assessment and treatment.

Background

Recent literature in the area of eating disorders has begun to question the validity of eating disorder diagnoses. As reasoned by Wonderlich (2007), new research is warranted by the belief that current diagnostic constructs do not accurately capture the disorders of eating recovered in their natural form. Rather, eating disorder diagnoses reflect man-made constructs

representative of collective wisdom, leaving them to be considered "open and falsifiable" (Wonderlich et al. 2007).

Anorexia Nervosa and Bulimia Nervosa

AN and BN are diagnosed on the basis of minimally met, more general characteristics. Anorexia nervosa, according to the DSM-IVTR, focuses on the biological outcomes and associated attitudes regarding body weight such as low BMI and amenorrhea, an intense fear of gaining weight, and a disturbance in the way one perceives one's body weight or shape (2000). This diagnosis can be further specified into either restricting-type or binge-eating-purging type, depending on the patient's overall engagement in or abstinence from binge-eating or purging behavior. Although these subtypes do add a new level of specificity to the diagnosis of AN, they are not behaviorally discriminate. For example, patients who engage in multiple purging behaviors (e.g. self-induced vomiting, laxative use, diuretic use) are diagnostically indistinguishable from patients who engage in just one purging behavior.

BN is defined by recurrent episodes of binge eating with compensatory behaviors such as self-induced vomiting, misuse of laxatives, diuretics, enemas, or other medications, fasting, or excessive exercise (American Psychiatric Association, 2000). The combination of binge eating and compensatory behavior must both occur at least twice a week for three months, on average. BN diagnosis also includes attitudinal behaviors, such as a self evaluation influenced by body weight or shape. Similar to AN, BN can be subtyped into two categories: purging type, or the engagement in purging behaviors (e.g. self induced vomiting, laxative use, diuretic use); and nonpurging type, or the use of a compensatory behavior not including purging behaviors (e.g. over exercising, diet pill use). Although BN does focus more on the behaviors of the individual, significant variations in type and frequency of behaviors are possible.

Eating Disorder Behaviors

ED behaviors can have a potentially devastating effect on the health of an individual due to the physiological consequences associated with an altered nutritional status, or calorie loss (Becker et al., 1999). A comprehensive understanding of ED behaviors and patterns across individuals are not specified by our current conceptualization of eating disorders; however, would be very valuable to understanding the individual behind the disease.

Diet Pill Use. Diet pill abuse is a relatively common compensatory behavior, endorsed by as many as 50% of those who engage in compensatory behaviors (Celio et al., 2006; Mitchell, Pomroy, & Huber, 1988; Roerig et al., 2003; Steffen, Roerig, Mitchell, & Crosby, 2006). In part of a comprehensive study of eating disorder behaviors, Reba-Harrselson et al. (2008) investigated the use of diet pills in individuals diagnosed with either AN or BN, by the individual's response to the question, "How many diet pills do you currently consume each week?" The goal of this study was to explicate relevant features of ED individuals engaging in diet pill abuse, such as an engagement in other purging behaviors (i.e. Vomiting, laxative use, diuretic use, emetic use; Reba-Harrelson et al., 2008). Researchers found that diet pill use was positively associated with a constellation of other compensatory behaviors (i.e. 'vomiting and other forms of purging') and was endorsed by a significant amount of patients diagnosed with all subtypes of anorexia nervosa and bulimia nervosa except for anorexia nervosa restricting type (RAN; Reba-Harrelson et al., 2008). This research suggests that diet pill use, a non-purging behavior, is associated with other purging behaviors and is a prevalent compensatory behavior regardless of eating disorder diagnosis.

Excessive Exercise. Excessive exercise within AN patients has been associated with longer inpatient treatment and shorter time to relapse after treatment (Shroff et al., 2006). A

study done by Shroff et al. (2006) examined the excessive exercise within a large and diagnostically diverse group of eating disordered females (n=1,857) by asking the question, "How much exercise did you engage in [at the worst point of this behavior]?" Exercise was deemed "excessive" if it interfered with important activities, was engaged in for more than 3 hours/day, was not suppressed at inappropriate times or places, or was engaged in despite a serious injury, illness, or medical complication (Shroff et al., 2006). Researchers found that excessive exercising was endorsed by 39% of the entire sample regardless of ED diagnosis. However significant differences between diagnoses did emerge; anorexia nervosa purging type (AN-P) had the highest rate of excessive exercisers (54%), suggesting a correlation between excessive exercise and other purging behaviors (i.e. self-induced vomiting, laxative use, diuretic use). Nevertheless, the results of this study are extremely limited by the lack of information surrounding the timeframe of excessive exercise, as well as its relation to the purging behaviors.

Laxative Abuse. The use of laxatives as a method of purging is an interesting phenomenon, given its delayed effects, its modest results (as compared to more immediate and extreme purging methods such as self-induced vomiting), and the negative social effects of loss of bowel control. It has even been suggested that this compensatory behavior serves as a method of self harm (Tozzi et al., 2006). The prevalence of purging behaviors in both community and clinical samples has been well examined and these findings suggest that laxative abuse varies widely, however, is rarely an individual's sole method of purging; eating disorder individuals who abuse laxatives also endorse additional purging behaviors such as self-induced vomiting, diuretic use, and enema use (Pryor, Wiederman, & McGilley, 1996; Tobin, Johnson, & Dennis, 1992; Tobin, Griffing, & Griffing, 1997; Tozzi et al., 2006). Tozzi and colleagues (2006) examined laxative use in a large sample (N = 1021) of eating disordered individuals by asking

them the question, "Did you use laxatives to avoid gaining weight?" Laxative abusers were then defined by a response that varied from those who used laxatives rarely (less than twice a week), sometimes (once a week), frequently (up to once daily), or very frequently (several times daily). Results indicated that laxative abuse was the second most frequent method of purging after self-induced vomiting, and was part of multiple purging techniques that were endorsed by approximately 50% of the sample (Tozzi et al., 2006).

Self-Induced Vomiting. Self-induced vomiting has been repeatedly characterized as the most prevalent purging behavior across eating disorder diagnoses, present in up to 39% of individuals diagnosed with AN and 90% of individuals diagnosed with BN (Ben-Tovim, Subbiah, Scheutz, & Morton; Garner, Garner, & Rosen, 1993). These findings are significant in comparison to rates of other compensatory behaviors in eating disorders and extremely worrisome given the dangerous psychological and physical side effects of the behavior. A study done by Reba et al. (2005) attempted to examine the relationship between self-induced vomiting and other features of eating disorder individuals, including eating disorder course and severity, personality traits, and Axis I and Axis II comorbidity, by posing the question, "Have you induced vomiting in order to avoid weight gain, or in order to feel relieved?" The differences that emerged between eating disordered individuals who did (i.e. all participants who indicated they had ever tried) or did not (i.e. all participants who indicated they had never trid) engage in self-induced vomiting centered around the domains of weight, alternative purging methods, and personality. There was also a strong negative correlation in women with purging-type ED vomiting and laxative and diuretic use.

Diuretic Use. A study done by Mitchell, Hatsukami, Eckert, & Pyle (1985) found that diuretic use was endorsed by 33.1% of a sample of 275 women who met the DSM-III criteria for

Bulimia Nervosa, indicating that it is a prevalent purging method in ED women. In a study that examined compensatory behaviors in a group of 69 women diagnosed with bulimia nervosa, it was found that diuretic use (i.e. using diuretics from once a week to up to four times a day) was associated with both laxative and diet pill use (Vaz, Penas, Ramos, Lopez-Ibor, & Guisado, 2001). This spectrum of more "pharmacological" behaviors was clustered separately from women who used vomiting as the preferred method for controlling weight, thus suggesting a negative correlation between vomiting and diuretic use.

Restriction and Fasting. Dieting, or dietary restriction, is one of the most prevalent behaviors in eating disordered individuals and can be described as limiting what one eats by imparting multiple demanding, and highly specific, dietary rules on oneself with the goal of controlling weight and shape (Fairburn et al., 2008). Dietary restriction and fasting are two ED behaviors considered "most typical" of eating disorder individuals and possibly not considered as serious as the more overtly noticeable purging behaviors. Restricting is an extremely prevalent compensatory behavior, especially within anorexic individuals, to the point that a subtype (anorexia nervosa restricting-type) was developed, which requires the negation of binge eating or purging behaviors (American Psychiatric Association, 2000).

In a similar study of eating disorder clusters, or natural groupings of eating disorder patients, Clinton and colleagues (2004) found that groups of women differentiated by a wider range of behavioral features than those of the current DSM diagnoses. This study examined 2 independent samples of eating disorder patients and subsequently identified 3 clusters which indirectly corresponded with current DSM-IV diagnoses. The first cluster, Anorexics, broadly corresponded to a diagnosis of anorexia nervosa without bingeing or vomiting. The second cluster, Generalized Eating Disorder, endorsed more severe eating disorder symptoms (e.g.

laxative abuse, compulsive exercise, poor body image) except for in the category of weight. The third cluster, Overeaters, showed patterns of overeating and increased weight. Interestingly, when these clusters were expanded, researchers found that clusters could be characterized by additional eating disorder behaviors and outcomes, such as low BMI and an engagement in such compensatory behaviors as restriction, fasting (or food avoidance), compulsive exercise, and laxative abuse. This study reinforces the value of drawing attention to additional eating disorder behaviors and presenting characteristics above and beyond diagnostic criteria (Sloan, Mizes & Epstein, 2004; Tozzi et al., 2006).

Temporal Constructs

As examined, current ED diagnoses are heavily dependent a few important behaviors and behavioral outcomes, such as the presence of bingeing and purging behaviors or the patient's BMI. However, aside from the time constraints included in the BN diagnosis (binge-purge cycle occurring at least twice per week over the course of three months), ED diagnoses disregard the occurrence of behaviors and behavioral patterns that may distinguish profiles of a behavior. For example, are there groups of days in which no behaviors are engaged? What other behavioral variables affect these days? These questions simply scratch the surface of what is possible when looking at the individual behind the eating disorder, as temporal pattering could be significant.

As identified by Smyth et al. (2009) literature is lacking regarding the frequency of eating disorder behaviors in 'real time' or how these frequencies may vary over the course of a time period. In a study by Smyth and colleagues (2009) researchers used ecological momentary assessment (EMA) to examine the temporal pattern of two ED behaviors in women diagnosed with BN. Over the two week period of data collection participants indicated their engagement in ED behaviors by answering the questions "I binge ate" or "I vomited" either when prompted by

the handheld computer or at the time in which the behavior occurred. Binge events showed to be least frequent in the early morning hours and peaked in the early afternoon and early nighttime. Results of vomiting showed a similar trend, lowest in the early morning and peaking twice later in the day. Results such as these indicate that trends in behavioral frequency do show effects based on time of day and day of week, thus suggesting the existence of ED behavioral patterns assume a temporal pattern that should be considered in approaches to treatment.

Ecological Momentary Assessment (EMA)

A wealth of information lies in examining individual profiles of ED behaviors, such as the daily behavioral patterns of individuals with ED. However, this information is highly susceptible to recall bias when captured by retrospective self reports (Stein & Corte, 2003), a standard method of data collection. Moreover, retrospective self reports fail to provide an accurate frequency of these behaviors on a daily basis, as they are neither recorded in "real time," nor recorded in the settings in which they naturally occur resulting in misrepresented data. Although retrospective self-reports are a valuable method to the collection of data for many variables such as demographic characteristics and stable personality traits there exist clear flaws in using retrospective self reports to collect data on ED behavior patterns (Smyth et al., 2009).

Ecological Momentary Assessment (EMA), as a collection of methods used to assess behaviors, has been explored in a variety of settings and with multiple tools. EMA is the method of data collection which, according to Stone and Shiffman (1994), can be defined by 4 qualities: 1) assessment of phenomena as they occur in a natural setting, 2) accurate assessments rely on careful timing, 3) assessments involve multiple, repeated observations, and 4) assessments are made in the subject's natural environment. EMA can be implemented using numerous methods, such as traditional paper and pencil diaries, personal hand-held computers or more recently with

Smart phone technology (Shiffman, Stone, & Hufford, 2008). Thus, EMA takes a temporally-sensitive approach to a new realm of specificity that previous global, retrospective reports could not attain, yet leaves the choice of technology and schedule of assessment to the researchers (Shiffman et al., 2008).

EMA technology is ideal to study dynamic behaviors that change over time and across situations, such as ED behaviors. This approach allows researchers to capture the behaviors in real time as they occur in their natural settings. For example, Hay and colleagues (1998) used EMA methods to measure bulimic symptoms in a community sample. Results showed that laxative abuse is prominent later in the day, and behaviors such as binge-eating, vomiting, and laxative abuse are often co-occurring. With this methodology, research might be better able to identify subpopulations of people based on distinct behavioral patterns; a step that is clinically important because the treatment outcome for any disorder is significantly impacted by its diagnosis (Wonderlich et al., 2007).

Objectives

The emphasis of the current study was to use cluster analysis to identify patterns of ED behavior in women diagnosed with either full threshold or sub threshold AN or BN. The variables used to cluster these women include percentage of binging, vomiting, over exercising, laxative pill use, diuretic pill use, diet pill use, restriction, and fasting episodes recorded using EMA technology. Other properties of the behavioral patterns included in this analysis include, the percentage of days in which no behavior was engaged, the groups of 2 or more days with no behavior, as well as the total number of behavioral episodes. As identified previous studies (Clinton et al., 2004; Hay et al., 1998) cluster analysis is an effective strategy to distinguish between groups that share distinct behavioral patterns.

Method

Overview

The current study is a secondary analysis of data originally collected as part of a randomized clinical trial examining the efficacy of a psychotherapy intervention designed to promote recovery and health in young adult women with AN and BN. The intervention, referred to as the Identity Intervention Program, sought to build new positive self-schemas that are distinct and separate from other conceptions of the self in memory as the means to promote behavioral change and healthy functioning. For this study, participants prospectively recorded ED behaviors using EMA methodology. Participants recorded ED behaviors for 4-fourteen day intervals at pre-intervention and immediate, 6 and 12-months post-intervention. The data used for the current study was collected as a part of the pre-intervention baseline data.

Participants

Women between the ages of 18 and 35 years who met diagnostic criteria for threshold or subthreshold anorexia nervosa or bulimia nervosa were eligible to participate in the parent study. Participants were recruited through community-based and internet advertisements, and health care provider referrals. Recruitment took place in the period between 2003 and 2005. The Midwestern urban communities in which recruitment occurred were in close proximity to a large state university and other smaller four-year and community colleges. Women interested in the study were asked to contact the research office by phone. A brief phone-screening interview that focused on eating disorder symptoms and current psychotropic medication use and psychotherapy treatment involvement was completed at the time of initial contact or a later convenient time. Women who were deemed eligible on the phone screening interview were invited to complete a two-step eligibility assessment that included the Structured Clinical

Interview for DSM-IV and a physical health assessment. An information session was scheduled prior to the screening interview if desired by the potential participant. Study procedures including the random assignment to treatment were discussed with the potential participant before the informed consent process. Informed consent was either signed at the orientation meeting or prior to the start of the SCID interview.

To be eligible to participate in the study, women had to meet the following criteria: 1) between the ages of 18 and 35 years and not pregnant, 2) meet DSM-IV full or subthreshold criteria for anorexia nervosa or bulimia nervosa, 3) take no prescribed psychotropic medication for at least 2 weeks prior to screening, and, 4) involved in no other form of psychotherapy. Subthreshold AN and BN were defined based on DSM-IV EDNOS criteria. Subthreshold AN criteria included: 1) all criteria for AN were met except for amenorrhea for 3 consecutive months or 2) all criteria for AN were met except that despite significant weight loss, weight was not $\leq$ 85% of ideal, and 3) endorsement of two items developed by Strober related to levels of distress and dysfunction associated with weight concerns and eating (Strober, Freeman, Lampert, Diamond & Kaye, 2000). Subthreshold BN criteria included: 1) all criteria for BN were met except binge and compensatory behavior cycles occurred at an average rate of 1 time weekly for 3 months or 2) all criteria for BN were met except purging behaviors were in response to the ingestion of a small amount of food. Women were excluded from participation if they met any of the following criteria: 1) a level of symptom severity that required inpatient treatment, 2) suicidality, 3) any lifetime history of schizophrenia, other DSM-IV Axis I psychotic disorders or mental retardation, or 3) concurrent DSM-IV Axis I disorder at threshold level.

Participants went through a two-step assessment phase to determine eligibility to participate. The first phase consisted of the process of informed consent, followed by

measurement of height and weight, completion of the Beck Depression Inventory as an initial suicide screen and the SCID. Three experienced clinicians who were trained in the administration of the SCID completed the diagnostic interviews. All SCID interviews and diagnoses were reviewed with the first author to confirm eligibility to participate. Those who met eligibility criteria based on the SCID returned for the second phase that included a physical assessment, blood laboratory studies and an EKG.

Measures

Eating Disorder Behaviors. Event-triggered EMA methodology (Stone & Shiffman, 1994) was used to prospectively measure 8 ED behaviors including self-induced vomiting, laxative use, diuretic use, diet pill use, excessive exercise, binge eating, food/calorie restriction and fasting. A menu-driven computerized questionnaire programmed for use on a handheld computer was used to record the behaviors. Items were derived from the EDE (Fairburn & Cooper, 1993) and the Questionnaire on Eating and Weight Patterns-Revised (Spitzer, Yanovski, & Marcus, 1994). Participants carried the project-provided handheld computer for 21 days and recorded all episodes of vomiting, laxative, diuretic, diet pill use, exercise and binge eating immediately after the behavior occurred. The first screen showed a list of the target behaviors. The next series of screens focused on the first behavior selected and consisted of questions to determine if the behavior met the DSM-IV definition. For example, endorsement of binge eating on the first screen then led to a series of questions about the quantity of food consumed, the time period of consumption and associated feelings of being out of control. At the end of each day, participants were asked to respond to questions about restricting and fasting over the last 24 hours. All entries were automatically entered with a date and time stamp. Reliability of EMA is supported by studies that have shown that ED behavioral patterns are non-reactive to the

approach. Studies demonstrating correspondence between EMA and EDE supports the validity (Stein & Corte, 2003).

Additionally, three subscales from the Eating Disorder Inventory (EDI; Garner, Olmstead, & Polivy, 1991) were used as additional clustering variables. These subscales included Drive for Thinness, Bulimia, and Body Dissatisfaction. The EDI is a widely used self-report measure of current eating attitudes and behaviors. It generates 8 subscales scores by summing scores across all items in a subscale from a set of 64 measures. Criterion-related and concurrent validity of the subscales have been shown with clinical and nonclinical samples (Garner, 1991).

Procedure

All data collection sessions were individual face-to-face sessions held in the outpatient clinic of a university hospital based GCRC. During the first data collection session paper-and-pencil questionnaires not addressed in this report were completed in a fixed order in single two hour session. Approximately two weeks later participants were oriented to the EMA procedures in a 45-minute session and the 21-day EMA period began. EMA data was back-up on a laptop computer weekly. The treatment protocols were 20-weeks in duration. Post-intervention measures were completed one, 6 and 12-months after completion of treatment and participants were paid $50 each point to defray transportation costs.

Data Coding and Statistical Method

As the first step in the data analysis, individual EMA data was displayed in a 3-dimensional histogram using EXCEL graphics package. For each histogram, the x-axis reflected days of EMA recording and the y-axis reflected the number of eating disorder behaviors. For each day, the number each specific behavior engaged in by the participant on a single day were

represented on the histogram frequency bars using color coding The individual histograms were used to content code a total of 12 properties of the behavioral patterns including:

Percent of each ED behavior: calculated by dividing the number of episodes of the target ED behavior divided by the total number of behaviors over the EMA period recorded by the individual.

Fasting: Participant purposefully took in no food for a period of several hours to control their shape and weight.

Restricting: Participant purposefully limited the amount of food or calories that they ate or dieted to control their shape or weight. This included the use of lower calorie meal replacement products such as Slim-Fast.

Bingeing: Participant ate what would objectively be considered an unusually large quantity of food with in a 2-hour period of time and accompanied by feelings of loss of control.

Over-Exercising: Participant exercised for $\geq$ 1.5 hours the purpose of controlling their shape and weight or to burn calories.

Diet Pills: Participant used pills or other substances for the purposes of burning calories, altering their appetite or metabolism for the purpose of controlling their shape and weight. Examples included diet pills, appetite suppressants, fat-binders, carb-cutters and metabolizers. Common brands may have included but were not limited to SlimFast, Trim Spa, Mega Green T, Alli Pills, Xenadrin, 7 day detox, or Leptovox.

Diuretic Use: Participant used water pills or other substances for the purpose of reducing the amount of water in their body to control their shape and weight. This included herbal pills and teas taken to reduce water weight.

Laxative Use: Participant took pills or other types of substances to make their bowels move, to get rid of food or calories to control their shape or weight. Examples include pills, liquids, suppositories, enemas. Common brands may include but are not limited to Ex-Lax, Docusate Sodium, Metamucil, Milk of Magnesia, Citrucel, or Fleet.

*Self-Induced Vomiting***:** Participant threw-up to control their shape or weight or to get rid of food.

Structural Variables

Percent of Days With No Behavior: Total number of days the participant refrained from engaging in any of the 8 eating disorder behaviors divided by the total number of days the participant recorded on the PDA.

On/Off Patterning: Total number of intervals of one or two days in which none of the eight eating disorder behaviors were used.

Total Number of Behavioral Episodes: The cumulative number of times the participant engaged in any of the eight eating disorder behaviors over the course of time they recorded on the PDA.

Additional variables used to determine the clinical meaningfulness of the cluster results

Total Number of Behaviors: The total number of distinct behaviors that were engaged in over the assessment period (1-8)

Chaotic Behavior Patterning: The number of "peaks" in a histogram; days displaying two or more behavioral episodes than immediate surrounding days, indicating that a participant's behavior "spiked".

Eating Disorder Inventory (EDI) Subscale Scores: Drive for Thinness, Body Dissatisfaction, and Bulimia.

Age: Participant's age at baseline data collection.

BMI: Participant's body mass index at baseline data collection, calculated by kg/m^2.

Eating Disorder Diagnosis: Diagnosis of participant at baseline data collection.

Statistical Analysis

Data analyses were carried out using Predictive Analytics SoftWare (PASW) version 18 (formerly known as SPSS). First, descriptive statistics and bivariate correlations across the 11 clustering variables were calculated using Pearson product-moment correlation. Next statistical analysis focused on two different cluster analysis methods: first, hierarchical cluster analysis and second, K-means cluster analysis. These are two of the most commonly used cluster analysis methods, yet, as discovered, yield very different results. Hierarchical cluster analysis was employed using the relatively robust average linkage method. The three-cluster result of this analysis was not sufficient, producing very imbalanced clusters (N = 53, N = 1, N = 1). Next, researchers used the centroid linkage method which yielded similar results to the average linkage method and thus was deemed an inappropriate method for this data. Finally, Ward's linkage method was employed and produced improved cluster results (N = 25, N = 36, N = 4), however, researchers still felt them to be insufficient. The unsatisfactory outcomes regardless of linkage method suggested that the hierarchical cluster analysis method was not suitable for the data at

hand. Thus, researchers employed K-means cluster analysis to detect meaningful groups of participants according to the 11 aforementioned clustering variables.

K-means cluster analysis allows the researcher to subjectively choose the optimal number of cluster solutions. After investigating both two- and three-cluster solutions, the three-cluster solution was identified as preferable due to more balanced cluster sizes and a subjectively more interesting result (N = 23, N = 32, N =10).

After identifying 3 cluster solutions, characteristics of each group were investigated by examining group differences across the 11 variables included in the cluster analysis. A one-way between-groups analysis of variance (ANOVA) was conducted to examine whether the mean differences of 11 the cluster groupings (1, 2, or 3).

Next, post hoc tests were completed to explore where these differences lie. Levene's test for homogeneity was conducted and variables that did violate the assumption of equal variance, Robust Tests of Equality of Means were conducted using the Welch test. Statistical significance between each pair of cluster groups was then shown through the Tukey HSD test or Dunnett's, with a significance level of $p \leq .05$. This process was then repeated with 6 exploratory variables that were not included in the original cluster analysis. Additionally, the final exploratory variable, eating disorder diagnosis, was categorical, and thus could not be included in the ANOVA. As a result, a Chi-square test for independence was employed to identify group associations within eating disorder diagnosis.

Results

A total of 149 women completed the screening measurements. A total of 46 women (30.9%) were ineligible to participate and 5 women (3.4%) declined participation. Additionally, 29 women (19.5%) dropped out of the study during the pre-intervention data collection. At the

time of data analysis, 4 cases were excluded due to insufficient EMA recordings. Thus, data from 65 women was analyzed.

Of these 65 women, 4 (6%) women met the criteria for anorexia nervosa, 2 (3%) women met the criteria for anorexia-sub threshold, 42 (65%) women met the criteria for bulimia nervosa, and 17 (26%) women met the criteria for bulimia nervosa sub-threshold**.** Participants were females between the ages of 18 and 37 years (M = 23.8 years, SD = 3.9 years). Racially, most participants (n = 52) self-identified as White, while others identified as Black (n = 3), Hispanic (n = 3), Asian (n = 2), and Other (n = 5). Few participants (n = 15) reported they lived alone, while most (n = 50) lived with at least one other person, in the form of a spouse, significant other, child/children, or friends. The majority participants in this study had never been married (n = 55) and had completed at least some college (n = 60). For employment, participants reported a diversity of types; predominantly, participants (n=22) considered themselves students. Completed diaries ranged from 11 to 28 days (M = 20.72), with the participants aiming to record for 22 days. An under-recording of data (i.e. recording times that are less than 22 days) was due to the participant's lack of adherence to PDA guidelines. An over-recording of data (i.e. recording time that exceed 22 days) were due to a discrepancy in PDA pick up times. For example, either the data collector or the participant was not able to meet until some number of days after the 22 day threshold, thus the participant continued to record until this pick up was possible.

Analysis of Correlations

Table 2 shows the bivariate analyses across the 11 clustering variables. There was a strong negative correlation between Number of Days No Behavior and Total Number of Behavioral Episodes (r = -.651, n = 65, p < .01), with greater number of days of no behavior

associated with a fewer number of total behavioral episodes. Similarly, a negative correlation was also shown to exist (r = -.463, n = 65, p < .01) suggesting that as the gaps of two or more days of no behaviors increases, the total number of behavioral episodes decreases. Additionally, as the number of days of no behavior increases, so does the number of gaps of two or more behaviors ("On/Off Patterning") (r = .600, n = 65, p < .01).

Less strong negative correlations were found between number of days of no behavior and percentage of restricting episodes (r = -0.278, n = 65, p < 0.05), percentage of over exercising episodes and percentage of vomiting episodes (r = -0.273, n = 65, p < 0.05), percentage of fasting episodes and percentage of vomiting episodes (r = -.304, n = 65, p < .05), and percentage of diet pill episodes and percentage of vomiting episodes (r = -0.246, n = 65, p < 0.05). It is interesting to note that vomiting is overwhelmingly negatively correlated with non-purging behaviors, such as over exercising, fasting, and diet pill episodes.

Interpretation and Labeling of Clusters

K-means cluster analysis produced three groups of participants (n = 23, n = 32, n = 10). In order to examine the characteristics of each of these three clusters, an ANOVA test was performed. From this ANOVA, the clusters can be distinguished on all 11 continuous variables that were continuous. Results showed the following three clusters:

Cluster 1 "High Frequency Engagers": Cluster 1 (n = 23, 35%) contained a significantly higher mean rate of total number of behavioral episodes (M = 49.96, SD = 19.72) than the other two cluster groups, indicating that this group of women had a high frequency of behaviors. This cluster also had the lowest mean percentages of days with no behavior (M = 5.55, SD = 6.55) and on/off behavior patterning (M = 0.09, SD = 0.29). From these statistics, we can assume this is a group of individuals who frequently engage in eating disorder behaviors

throughout the day, with very few days of no behavior. Self-induced vomiting was engaged in the most by this group (*M* = 49.10, *SD* = 17.69), with moderate levels of restricting (*M* = 21.42, *SD* = 11.99) and fasting (*M* = 4.58, *SD* = 6.40). Also, this group showed low levels of over exercising, diet pill, and diuretic pill engagements.

Cluster 2 "Dabblers": Cluster 2 (*n* = 32, 49%) shows the highest percentage of engagements in multiple behaviors: fasting (*M* = 9.89%, *SD* = 17.18), restricting (*M* = 51.48%, *SD* = 20.64), over exercising (*M* = 6.67%, *SD* = 8.61), diet pill use (*M* = 6.51%, *SD* = 13.67), diuretic pill (*M* = .95%, *SD* = 3.35), and laxative pill use (*M* = 1.65%, *SD* = 4.38). Thus, this cluster can be characterized as a group of women who do not have a significantly high number of eating disorder behavior episodes (*M* = 32.47, *SD* = 15.08), yet engage in a wide variety of ED behaviors often significantly more than the other two clusters. As previously noted, individuals engaging in multiple purging behaviors (ie. Self-induced vomiting, laxative abuse, diuretic abuse, or diet pill abuse) put themselves at much greater risk for detrimental than individuals engaging in solely one purging method, such as more severe eating disorder symptoms (Grave, Calugi, & Marchesini, 2009). Thus, this group presents a very concerning pattern.

Cluster 3 "Sporadic Binge-Vomiters": Cluster 2 (*n* = 10, 15%) showed the highest rate of percentage of days in which no behavior occurred (*M* = 59.46 %, *SD* = 28.44) and on/off behavioral patterning (*M* = 1.40, *SD* = 1.08). These variables indicated that this cluster group engaged in behaviors for less than half of the days they were recording on the PDA, and a significant amount more of these days were in groups of two or more than those in the other two clusters. Additionally, this cluster shows the highest rate of bingeing episodes (*M* = 18.54%, *SD* = 19.62) and very high rate of self-induced vomiting episodes (*M* = 43.86%, *SD* = 29.47). This

group no episodes of over exercising, diet pill use, diuretic use, or laxative use (M = 0.00, SD = 0.00). These patterns indicate that on low frequency bingeing and vomiting behaviors.

An additional 7 variables were used to determine the clinical meaningfulness of the cluster results. Significantly differences were found between the three clusters in the total number of behaviors used ($p < .000$), EDI score on Drive for Thinness ($p < .05$), EDI score on Bulimia ($p < .01$), and age ($p < .05$). Clusters 1 (High Frequency Engagers) and 2 (Dabblers) engaged in a significantly greater amount of eating disorder behaviors (M = 4.22, SD = 1.20; M = 4.22, SD = 1.26) than Cluster 3 (Frequent Binge-Vomiters; M = 2.10, SD = 1.37). High frequency engagers scored significantly higher on the EDI Drive for Thinness than Sporadic Binge-Vomiters (M = 14.78, SD = 5.66; M = 9.50, SD = 5.58). Additionally, High Frequency Engagers (M = 13.74, SD = 5.31) scored significantly higher on the EDI Bulimia scale than both Dabblers (M = 9.77, SD = 6.19) and Sporadic Binge-Vomiters (M = 7.20, SD = 6.64). A significant difference was also found between the age of High Frequency Engagers (M = 25.23, SD = 3.96) and Dabblers (M = 22.56, SD = 3.68).

Discussion

The overall goal of this study was to identify in a sample of women diagnosed with AN and BN natural groupings that reflect distinct behavioral patterns that extend beyond the eating disorder diagnosis. We began our analysis by exploring patterns of association among the eating disorder behavioral characteristics and found surprisingly few meaningful associations. However, results of a cluster analysis show that three groups of women emerged that reflect distinct behavioral patterns. Further, these groups differ in age and other eating disorder attitudes and behaviors, yet, the ED diagnostic categories were approximately equally distributed across the groups. Taken together these results support the view that behavioral patterns cut

across the eating disorder diagnoses and that each diagnostic category itself may be comprised of a heterogeneous group of behavioral patterns.

To our knowledge, this is the first study to have explored a wide variety of ED behaviors over such a long time period using prospective daily measurement of behaviors, or EMA, technology. Thus, the data that is comparable to this study must be pieced together from various other research projects. For example, Reba et al. has conducted numerous research studies using a large sample size of participants in order to assess patterns of associations between specific behaviors including vomiting, diet pill use, and excessive exercise (Reba et al., 2005; Shroff, Reba et al., 2006; Reba-Harrelson et al., 2008). Results from these studies showed a positive association between diet pill use and vomiting, as well as a positive association between diet pill use and other purging behaviors. Results of our study contrast these findings, showing a significant negative correlation between diet pill use and self induced vomiting. Similar to results from Tozzi et al. (2006), vomiting was nevertheless found to be a very prevalent eating disorder behavior in this sample.

Additionally, purging and non-purging behaviors were found to be significantly negatively associated. The percentage of excessive exercise episodes, a non-purging compensatory behavior, was negatively correlated with the percentage of self-induced vomiting episodes, a purging behavior. Similarly, the percentage of episodes of diet pill use, a non-purging behavior, was found to be negatively associated with the percentage of self-induced vomiting episodes. These findings further support the notion that purging and non-purging behaviors are distinct in nature, such as suggested by DSM subtyping.

Exploration of group differences in the 11 eating disorder characteristics used to complete the cluster analysis revealed the first group, labeled High Frequency Engagers, reported the

highest number of total behavioral episodes across the recording period, fewest days with no behaviors and generally no gaps in behaviors of 2 or more days. Women in this group engaged in binge eating, restricting and fasting behaviors most frequently with low levels of over-exercise, diet pill, diuretic and laxative use. Cluster 2, or the group labeled Dabblers, reported the highest percentage of behavioral episodes in fasting, restricting, over-exercising, diet pill use, diuretic use, and laxative use. This group also reported the lowest engagement in both bingeing and self-induced vomiting episodes. Finally, the third cluster, labeled Sporadic Binge-Vomiters, reported the lowest total number of behavioral episodes across the recording period, the greatest percentage of days with no eating disorder behavior and many gaps in behavior of 2 or more days. This group did not engage in over-exercising, diet pill use, diuretic use and laxative use, however, reported the highest percentage of bingeing episodes and a very high percentage of self-induced vomiting.

Differences among the High Frequency Engagers, Dabblers, and Sporadic Binge-Vomiters on 7 additional demographic and ED variables were also found. Age differed significantly across the 2 of the 3 clusters, with High Frequency Engagers being the oldest and Dabblers being the youngest. These are interesting results, as High Frequency Engagers also show a more stable, consistent pattern of behaviors across days while Dabblers engage in the same breadth of behaviors but with greater severity and on fewer days. These results suggest that with age behavioral patterns may consolidated and stable disorder. Clusters 1 and 2 endorsed a significantly greater total number of behaviors than Cluster 3, indicating that Cluster 3 (Sporadic Binge-Vomiters) does show signs of having a more pure behavioral trajectory, with an intense focus on bingeing and vomiting.

Direct comparisons between the results of this study and the results of previous cluster analyses are very complicated due to differing methodology and more restricted variables, yet some important cluster similarities can be discerned. Clinton et al. (2004) examined a 3 cluster solution produced by 10 clinical eating disorder variables that were of primary significance for diagnosing eating disorders. This study resulted in clusters that were similar, although not identical, to ED diagnoses such as AN, binge eating disorder, and eating disorder not otherwise specified. By dissembling these three clusters into behavioral patterns, we are able to see that our cluster of Sporadic Binge-Vomiters is similar to Clinton and colleagues (2004) cluster representative of binge or overeating and high weight. Also, similar to our cluster of Dabblers, Clinton and colleagues identified a cluster with a greater frequency of symptoms but with a lower weight (Clinton et al., 2004). Interestingly, it was found that in both the current study and the study by Clinton et al. (2004) eating disorder diagnoses were not homogeneous to one cluster; rather, eating disorder diagnoses were spread between each of the three clusters (Clinton et al., 2004).

The few studies that are similar to our current project examine similar variables; however, do so through retrospective reports in the form of structured interviews (Grave et al., 2009; Reba et al., 2005; Reba-Harrelson et al., 2008; Shroff et al., 2006; Tozzi et al., 2006). This form of data collection that is highly susceptible to recall bias and thus, it can be inferred that EMA studies, such as the current one, might create a more accurate picture of the individuals' eating disorder behaviors (Smyth et al., 2009). As pointed out by Becker et al. (1999), it has been questioned that fear of judgment might inhibit participants from disclosing the true nature of "embarrassing behaviors" in clinical interviews, thus EMA technology might also help eliminate this fear of embarrassment and lead to more valid data.

Limitations of this study include the relatively small sample size and the low number of participants with AN diagnoses. In the future, studies similar to this should be conducted with patients equally distributed across eating disorder diagnoses, including the diagnoses of Eating Disorder Not Otherwise Specified and Binge Eating Disorder, as well as eating disorder subtypes (PAN, RAN, PBN, RBN). Although no sample is perfect, a more balanced sample would better shed light on the correlation between eating disorder diagnosis and cluster groupings. A third important limitation of the study is the uneven number of recording days across participants. This limitation, due to variability in participant compliance with the protocol, raises concerns about the reliability of the data and validity of the identified patterns. Comparison of the number of days of recordings across the 3 cluster groups showed approximately equivalent means, standard deviations and range of days recording providing some evidence that this limitation may not significant influence the results. Additionally, it would be beneficial to examine the course of these 11 eating disorder variables and how they might be affected by interventions such as the one tested in our main study. Examining post-intervention data in the same manner would shed light on how these variables might be affected, or how strong the relationships between variables might be when they are affected by the intervention.

Studies such as this are of high value to clinicians, as they allow a deeper, more exhaustive look into the daily life of an ED sufferer. By examining the breadth of an eating disorder sufferer's behavior to the best of our ability, we are not attempting to change the diagnostic categories of eating disorders, but rather widen the scope of understanding other behaviors that are at play and to move closer to developing refined, more personally tailored approaches to intervention.

References

APA Help Center from the American Psychological Association. (2009). *Facts and Statistics.* Retrieved on April 1, 2009, from http://www.apahelpcenter.org/articles/topic.php?id=6#Eating%20Disorders.

APA. (1994*). Diagnostic and Statistical Manual of Mental Disorders (DSM-IV)* (4th edn). American Psychiatric Association: Washington, DC.

Augustus-Horvath, C., & Tylka, T. L. (2009). A test and extension of objectification theory as it predicts disordered eating: Does women's age matter? *Journal of Counseling Psychology, 56*(2), 253-265.

Becker, A. E., Grinspoon, S. K., Klibanski, A., & Herzog, D. B. (1999). Current concepts: Eating disorders. *The New England Journal of Medicine, 340*(14), 1092-1098.

Ben-Tovim, D., Subbiah, N., Scheutz, B., & Morton, J. (1989). Bulimia: Symptoms and syndromes in an urban population. *Australian and New Zealand Journal of Psychiatry, 23*(1), 73-80.

Celio, C. I., Luce, K. H., Bryson, S. W., Winzelberg, A. J., Cunning, D., Rockwell, R., et al. (2006). Use of diet pills and other dieting aids in a college population with high weight and shape concerns. *International Journal of Eating Disorders*, 39, 492-497.

Clinton, D., Button, E., Norring, C., & Palmer, R. (2004). Cluster analysis of key diagnostic variables from two independent samples of eating-disorder patients: Evidence for a consistent pattern. *Psychological Medicine: A Journal of Research in Psychiatry and the Allied Sciences, 34*(6), 1035-1045.

Dalle Grave, R., Calugi, S., & Marchesini, G. (2009). Self-induced vomiting in eating disorders: Associated features and treatment outcome. *Behaviour Research and Therapy, 47*(8), 680-684.

Fairburn, C.G. & Cooper, Z. (1993). The eating disorder examination. In: Fairbum CG, Wilson GT, editors. Binge eating: nature, assessment & treatment. 12th ed. New York(NY): Guilford Press; 317-60.

Fairburn, C. G., Cooper, Z., Shafran, R., Bohn, K., Hawker, D. M., Murphy, R., et al. (2008). Dietary restraint, dietary rules and controlling eating. In C. G. Fairburn (Ed.), *Cognitive behavior therapy and eating disorders*. (pp. 124-135). New York, NY US: Guilford Press.

Garner, D. (1991). Eating Disorders Inventory 2 - Professional Manual. Odessa, FL: Psychological Assessment Resources.

Garner, D. M., Garner, M. V., & Rosen, L. W. (1993). Anorexia nervosa 'restricters' who purge: Implications for subtyping anorexia nervosa. *International Journal of Eating Disorders, 13*(2), 171-185.

Garner, D. M., Olmstead, M. P., & Polivy, J. (1983). Development and validation of a multidimensional eating disorder inventory for anorexia nervosa and bulimia. *International Journal of Eating Disorders.* 2:15-34.

Hay, P. J., Fairburn, C. G., & Doll, H. A. (1996). The classification of bulimic eating disorders: a community-based cluster analysis. *Psychological Medicine, 26*, 801-812.

Mitchell, J. E., Pomroy, C., & Huber, M. (1988). A clinician's guide to the eating disorders medicine cabinet. *International Journal of Eating Disorders , 7*, 211-223.

Pryor, T., Wiederman, M. W., & McGilley, B. (1996). Laxative abuse among women with eating disorders: an indication of psychopathology? *International Journal of Eating Disorders, 20*(13), 8.

Reba, L., Thornton, L., Tozzi, F., Klump, K. L., Brandt, H., Crawford, S., et al. (2005). Relationships between features associated with vomiting in purging-type eating disorders. *International Journal of Eating Disorders, 38*(4), 287-294.

Reba-Harrelson, L., VonHolle, A., Thornton, L., Klump, K., Berrettini, W., Brandt, H., et al. (2008). Features associated with diet pill use in individuals with eating disorders. *Eating Behaviors, 9*(1), 73.

Ricca, V., Castellini, G., Lo Sauro, C., Mannucci, E., Ravaldi, C., Rotella, F., et al. (2010). Cognitive-behavioral therapy for threshold and subthreshold anorexia nervosa: A three-year follow-up study. *Psychotherapy and Psychosomatics, 79*(4), 238-248.

Roerig, J. L., Mitchell, J. E., Zwaan, M. d., Wonderlich, S. A., Kamran, S., Engbloom, S., et al. (2003). The eating disorders medicine cabinet revisited: A clinicians's guide to appetite suppressants and diuretics. *International Journal of Eating Disorders, 33*(4), 443-457.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology, 4*, 1-32.

Shroff, H., Reba, L., Thornton, L. M., Tozzi, F., Klump, K. L., Berrettini, W. H., et al. (2006). Features associated with excessive exercise in women with eating disorders. *International Journal of Eating Disorders, 39*(6), 454-461.

Sloan, D. M., Mizes, J. S., & Epstein, E. M. (2005). Empirical classification of eating disorders. *Eating Behaviors, 6*(1), 53-62.

Sloan, D. M., Mizes, J. S., & Epstein, E. M. (2005). Empirical classification of eating disorders. *Eating Behaviors, 6*(1), 53-62.

Smyth, J. M., Wonderlich, S. A., Sliwinski, M. J., Crosby, R. D., Engel, S. G., Mitchell, J. E., et al. (2009). Ecological momentary assessment of affect, stress, and binge-purge behaviors: Day of week and time of day effects in the natural environment. *International Journal of Eating Disorders, 42*(5), 429-436.

Spitzer, R., Yanovski, S. Z., Marcus, S. (1994). Questionnaire on Eating and Weight Patterns-Revised (QEWP-R). Pittsburgh, PA: *Behavioral Measurement Database Services*.

Steffen, K. J., Roerig, J. L., Mitchell, J. E., & Crosby, R. D. (2006). A survey of herbal and alternative medication use among participants with eating disorder symptoms. *International Journal of Eating Disorders, 39*(8), 741-746.

Stein, K. F. & Corte, C. (2003). Ecological momentary assessment of eating disordered behaviors. *International Journal of Eating Disorders*. 34, 349-60.

Stone, A. A., & Shiffman, S. (1994). Ecological momentary assessment (EMA) in behavorial medicine. *Annals of Behavioral Medicine, 16*(3), 199-202.

Strober, M., Freeman, R., Lampert, C., Diamond, J., & Kaye, W. (2000). Controlled family study of anorexia nervosa and bulimia nervosa: Evidence of shared liability and transmission of partial syndromes. *The American Journal of Psychiatry, 157*(3), 393-401.

Tobin, D. L., Griffing, A., & Griffing, S. (1997). An examination of subtype criteria for bulimia nervosa. *International Journal of Eating Disorders, 22*(2), 179-186.

Tobin, D. L., Johnson, C. L., & Dennis, A. B. (1992). Divergent forms of purging behavior in bulimia nervosa patients. *International Journal of Eating Disorders, 11*(1), 17-24.

Tozzi, F., Thronton, L. M., Mitchell, J., Fichter, M. M., Klump, K. L., Lilenfeld, L. R., et al. (2006). Features associated with laxative abuse in individuals with eating disorders. *Psychosomatic Medicine, 68*(3), 470-477.

Turner, H., & Bryant-Waugh, R. (2004). Eating disorder not otherwise specified (EDNOS): Profiles of clients presenting at a community eating disorder service. *European Eating Disorders Review, 12*(1), 18-26.

Vaz, F. J., Peñas, E. M., Ramos, M. I., López-Ibor, J. J., & Guisado, J. A. (2001). Subtype criteria for bulimia nervosa: Short- versus long-term compensatory behaviors. *Eating Disorders: The Journal of Treatment & Prevention, 9*(4), 301-311.

Wonderlich, S. A., Joiner, T. E., Jr., Keel, P. K., Williamson, D. A., & Crosby, R. D. (2007). Eating disorder diagnoses: Empirical approaches to classification. *American Psychologist, 62*(3), 167-180.

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Table 1

Mean and Standard Deviation of Clustering Variables

Clustering Variables	*Mean*	*SD*
% of Days No Behavior	16.62	23.77
On/Off Behavior Patterning	0.43	0.81
Total # of Behavioral Episodes	36.40	19.59
% of Behavioral Episodes		
Fasting	7.33	14.09
Restricting	35.76	23.30
Bingeing	14.63	11.99
Over Exercising	3.90	7.23
Diet Pills	4.20	10.38
Diuretic Pills	0.81	2.78
Laxative Pills	1.33	3.87
Vomiting	28.71	25.72

Table 2

Intercorrelations between Clustering Variables

Clustering Variables	Percentage of Days No Behavior	On/Off Patterning	Total Number of Behavioral Episodes	Proportion of Fasting Episodes	Proportion of Restricting Episodes	Proportion of Bingeing Episodes	Proportion of Over-Exercising Episodes	Proportion of Diet Pill Episodes	Proportion of Diuretic Pill Episodes	Proportion of Laxative Pill Episodes	Proportion of Vomiting Episodes
Percentage of Days No Behavior	-	.600**	-.651**	-.152	-.278*	-.010	-.188	-.146	.018	-.136	.055
On/Off Patterning	-	-	-.463**	-.175	.047	.033	-.164	-.068	.120	-.094	.131
Total Number of Behavioral Episodes	-	-	-	.118	-.085	.046	.073	.209	.074	.081	.181
Proportion of Fasting Episodes	-	-	-	-	-.046	-.211	.044	.022	.043	.058	-.304*
Proportion of Restricting Episodes	-	-	-	-	-	-.219	.215	.009	.066	.043	-.583**
Proportion of Bingeing Episodes	-	-	-	-	-	-	-.164	-.211	.004	-.113	.200
Proportion of Over-Exercising Episodes	-	-	-	-	-	-	-	-.081	.017	-.092	-.273*
Proportion of Diet Pill Episodes	-	-	-	-	-	-	-	-	-.036	.138	-.246*
Proportion of Diuretic Pill Episodes	-	-	-	-	-	-	-	-	-	.227	-.162
Proportion of Laxative Pill Episodes	-	-	-	-	-	-	-	-	-	-	-.154
Proportion of Vomiting Episodes	-	-	-	-	-	-	-	-	-	-	-

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3

Mean and standards deviations of Clustering Variables across Cluster Solutions

	Cluster 1 High Frequency Engagers (*n* = 23)	Cluster 2 Dabblers (*n* = 32)	Cluster 3 Sporadic Binge-Vomiters (*n* = 10)	F	Cluster Comparison
% of days No Behavior	5.55 ± 6.55	11.19 ± 13.72	59.46 ± 28.44	.000[a]	1-2 2-3* 1-3*
On/Off Behavior	0.09 ± 0.29	.38 ± .75	1.40 ± 1.08	.002[a]	1-2 2-3* 1-3*
Total # of Behavioral Episodes	49.96 ± 19.72	32.47 ± 15.08	14.80 ± 9.78	.000[b]	1-2* 2-3* 1-3*
% of Behavioral Episodes					
Fasting	4.58 ± 6.40	9.89 ± 17.18	0.46 ± 1.44	.001[a]	1-2 2-3 1-3
Restricting	21.42 ± 11.99	51.48 ± 20.64	17.15 ± 18.44	.000[b]	1-2* 2-3* 1-3
Bingeing	17.50 ± 11.79	10.83 ± 8.21	18.54 ± 19.62	.068[a]	-
Over-Exercising	1.75 ± 4.97	6.67 ± 8.61	0.00 ± 0.00	-	-
Diet Pill Use	2.82 ± 5.68	6.51 ± 13.67	0.00 ± 0.00	-	-
Diuretic Use	0.67 ± 2.21	.95 ± 3.35	0.00 ± 0.00	.630[b]	-
Laxative Use	1.45 ± 3.94	1.65 ± 4.38	0.00 ± 0.00	.498[b]	-
Self-Induced Vomiting	49.10 ± 17.69	8.90 ± 11.08	43.86 ± 29.47	.000[a]	1-2* 2-3* 1-3

Note. Mean and standard deviations in bracket are reported for continuous variables.

[a] Welch test of Robust Equality of Means was used due to the violation of the homogeneity of variance assumption.

[b].F-test was used

*. Indicates significant differences between clusters.

Table 4

Mean and standards deviations of additional variables across Cluster Solutions

	Cluster 1 High Frequency Engagers (*n* = 23)	Cluster 2 Dabblers (*n* = 32)	Cluster 3 Sporadic Binge-Vomiters (*n* = 10)	F	Cluster Comparison
Total # of Behaviors Used	4.22 ± 1.20	4.22 ± 1.26	2.10 ± 1.37	.000[b]	1-2 2-3* 1-3*
Chaotic Behavior Pattern	1.70 ± 1.22	1.16 ± 1.27	1.30 ± 1.25	.291[b]	-
EDI Scores					
Drive for Thinness	14.78 ± 5.66	14.00 ± 5.23	9.50 ± 5.58	.038[b]	1-2 2-3 1-3*
Bulimia	13.74 ± 5.31	9.77 ± 6.19	7.20 ± 6.64	.009[b]	1-2* 2-3 1-3*
Body Dissatisfaction	15.86 ± 7.08	14.97 ± 7.72	12.10 ± 6.14	.399[b]	-
Age	25.23 ± 3.96	22.56 ± 3.68	24.80 ± 4.08	.036[b]	1-2* 2-3 1-3
BMI	23.22 ± 5.88	22.49 ± 6.36	23.73 ± 6.23	.837[b]	-
ED Diagnosis					
AN	1 (25%)	1 (25%)	2 (50%)		
AN-S	1 (50%)	1 (50%)	0 (0%)		
BN	20 (48%)	16 (38%)	6 (14%)		
BN-S	1 (6%)	14 (82%)	2 (12%)		

Note. Mean and standard deviations in bracket are reported for continuous variables. Frequency and percentages are reported for categorical variables. Welch and Dunnett's T-3 tests were used to determine significant cluster comparisons.

[a] Welch test of Robust Equality of Means was used due to the violation of the homogeneity of variance assumption.

[b] F-value was used due to the not violating the homogeneity of variance assumption.

*. Indicates significant differences between cluster solutions.