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### Authors

Lavender, Jason M  
Utzinger, Linsey M  
Crosby, Ross D  
[et al.](#)

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## A Naturalistic Examination of the Temporal Patterns of Affect and Eating Disorder Behaviors in Anorexia Nervosa

Jason M. Lavender, Ph.D.<sup>1,2,\*</sup>, Linsey M. Utzinger, Psy.D.<sup>1,2</sup>, Ross D. Crosby, Ph.D.<sup>1,2</sup>, Andrea B. Goldschmidt, Ph.D.<sup>3</sup>, Jo Ellison, Ph.D.<sup>1</sup>, Stephen A. Wonderlich, Ph.D.<sup>1,2</sup>, Scott G. Engel, Ph.D.<sup>1,2</sup>, James E. Mitchell, M.D.<sup>1,2</sup>, Scott J. Crow, M.D.<sup>4,5</sup>, Carol B. Peterson, Ph.D.<sup>4,5</sup>, and Daniel Le Grange, Ph.D.<sup>6</sup>

<sup>1</sup>Neuropsychiatric Research Institute

<sup>2</sup>The University of North Dakota School of Medicine and Health Sciences

<sup>3</sup>The University of Chicago

<sup>4</sup>The University of Minnesota

<sup>5</sup>The Emily Program

<sup>6</sup>University of California, San Francisco

### Abstract

**Objective**—Evidence supports the presence of significant variability in the timing of affective experiences and eating disorder (ED) behaviors across ED populations. This study examined the naturalistic timing of affective states and ED behaviors in anorexia nervosa (AN).

**Methods**—Women ( $N = 118$ ) with full or subthreshold *DSM-IV* AN completed two weeks of ecological momentary assessment (EMA) involving self-reports of affect and ED behaviors. Patterns of positive affect, negative affect, and tension/anxiety across hours of the day and days of the week were examined using linear mixed models. Variation in ED behavior occurrence (i.e., binge eating, vomiting, exercise, meal skipping, and self-weighing) across hours of the day and days of the week was examined using general estimating equations.

**Results**—Results revealed significant variation in tension/anxiety across hours of the day; there were no significant associations between time of day and negative or positive affect. All affective variables significantly varied across days of the week, with both negative affect and tension/anxiety highest in the middle of the week and lowest on the weekends. The ED behaviors all significantly varied across hours of the day, with binge eating and vomiting most common in later hours, exercise and self-weighing most common in earlier hours, and meal skipping most common at times corresponding to breakfast and lunch. ED behaviors did not significantly vary across days of the week.

\*Correspondence concerning this article should be addressed to Jason M. Lavender, Neuropsychiatric Research Institute, 120 S. 8<sup>th</sup> St., Fargo, ND 58103. jlavender@nri.fargo.com.

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**Conclusion**—The significant patterns of variation in the timing of affective experiences and ED behaviors may have utility in informing theories and interventions for AN.

### Keywords

anorexia nervosa; emotion; affect; ecological momentary assessment; timing

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## Introduction

Numerous theoretical models describing the etiology and/or maintenance of eating disorders (EDs), including anorexia nervosa (AN), have been proposed. Included among these are the transdiagnostic model [1], the emotion avoidance model [2], the cognitive-interpersonal model [3], and the emotion dysregulation model [4]. Treatments specifically corresponding to several of these models have also been developed, such as Enhanced Cognitive Behavioral Therapy [5] and Emotion Acceptance Behavior Therapy [6,7]. Although these conceptualizations and associated treatments posit different constructs as most central to the symptoms characterizing AN, a common theme is the identification of variables that may promote ED behaviors (e.g., binge eating, purging, restriction, excessive exercise), including dispositional factors (e.g., personality pathology, impulsivity), cognitive and affective constructs (e.g., overvaluation of weight/shape, depression, anxiety), and situational/environmental variables (e.g., interpersonal stressors, food cues, prolonged restriction).

Prior findings in AN using data collected via ecological momentary assessment (EMA; i.e., repeated assessments completed in real-time in the participant's natural environment) have addressed the role of affective variables in relation to the occurrence of ED behaviors. Of particular relevance to the current study, previous results from the sample utilized in this investigation have indicated that (a) negative affect increases and positive affect decreases prior to binge eating and purging behaviors [8], (b) negative affect on a given day predicts the likelihood of restriction on the following day [8], (c) there are distinct patterns of variability in the daily experience of anxiety, which differentially relate to the occurrence of ED behaviors [9], and (d) associations between ED psychopathology and certain affective constructs (e.g., affective lability) appear to be stronger when affect is assessed via EMA versus traditional self-report [10]. Taken together, these findings support the salience of affect in relation to ED symptoms in AN, as well as demonstrating the utility of EMA as a method for examining constructs of relevance to AN that may be best understood in a momentary context.

A variable inherent to conceptualizing the associations described above is time (e.g., the timing of affective experiences in relation to the occurrence of ED behaviors). However, beyond examining the temporal nature of the relationship between affect and ED behaviors, there is also utility in understanding the broader temporal context of affective experiences and ED behaviors in AN. Specifically, characterizing the general timing of ED behaviors in this population may inform conceptualizations of the etiology and/or maintenance of the disorder, as well as providing information relevant to treatment (e.g., via the identification of situational factors that may correspond to times that are characterized by elevated risk for ED behaviors). Additionally, given evidence noted above suggesting an increased likelihood

of ED behaviors during times of greater emotional distress, as well as research suggesting that much of the variability in an individual's affective experiences can be accounted for by differences in momentary (e.g., current context) versus dispositional (e.g., personality) variables [11], understanding the timing of affective experiences in AN may have further clinical utility. In particular, such information could provide some guidance for clinical interventions by helping providers and patients anticipate and plan for times in which they may be most vulnerable to aversive affective states and engaging in ED behaviors.

Given these potential benefits of characterizing the typical timing of affective experiences and ED behaviors in AN, as well as the additional benefit of providing a broader context for considering related findings that have been previously reported, the goal of this investigation was to elucidate the temporal characteristics of affective experiences and ED behaviors in AN. Specifically, the extent to which these variables significantly varied across hours of the day and days of the week was examined. Affective variables in this study included negative affect, positive affect, and tension/anxiety. ED behaviors that were investigated included self-reported binge eating, self-induced vomiting, exercise, meal skipping, and self-weighing. This descriptive investigation was considered exploratory and hypothesis-generating, thus specific hypotheses were not made.

## Methods

### Participants and Procedure

Participants were 118 females (age:  $25.3 \pm 8.4$  years; body mass index:  $17.2 \pm 1.0$  kg/m<sup>2</sup>) with a diagnosis of AN ( $n = 59$ ) or subthreshold AN ( $n = 59$ ) based on *Diagnostic and Statistical Manual of Mental Disorders* (4<sup>th</sup> Edition: *DSM-IV*; [12]) criteria. Seventy-three (61.9%) participants were diagnosed with AN restricting type and 45 (38.1%) were diagnosed with AN binge eating-purging type. Data collection occurred at three sites in the Midwestern United States (Fargo, ND, Minneapolis, MN, Chicago, IL), and participants were eligible if they were female, at least 18 years of age, and met criteria for full *DSM-IV* AN or subthreshold AN.

After completing a phone screen and attending an initial informational meeting, participants attended two assessment visits during which they: (a) provided written informed consent, (b) completed laboratory tests and a screening physical examination to ensure medical stability, and (c) completed self-report measures and structured interviews. After two practice days of EMA (for which feedback about compliance was provided by research personnel), participants subsequently completed the two-week EMA protocol. Participants were signaled at six semi-random times (determined by random selection of times around six "anchor points") throughout the waking hours of the day. When signaled, participants were asked to rate their positive affect, negative affect, and tension/anxiety. Participants were also asked to initiate a report following the occurrence of certain ED behaviors, and at each random signal were given the opportunity to report recent ED behaviors that had not been previously recorded. Participants also completed reports at the end of each day before bedtime. The study was approved by the institutional review board at each study site. Additional methodological details and information on participant characteristics have been previously reported [8].

## Measures

**Diagnosis**—The Structured Clinical Interview for DSM-IV Axis I Disorders, Patient Edition (SCID-I/P) [13] was administered at baseline to assess DSM-IV diagnostic criteria for full and subthreshold AN.

**EMA Affect**—Momentary positive and negative affect were assessed using 16 items from the Positive and Negative Affect Schedule – Expanded Form (PANAS – X) [14] that were selected based on high factor loadings and theoretical relevance to AN. Negative affect items included: afraid, angry at self, ashamed, nervous, disgusted, dissatisfied with self, distressed, and sad ( $\alpha = .94$ ). Positive affect items included: strong, enthusiastic, proud, attentive, happy, energetic, confident, and cheerful ( $\alpha = .92$ ). Participants also completed 8 items from the Profile of Mood States (POMS) [15] tension/anxiety scale: relaxed (reverse coded), on edge, restless, tense, anxious, uneasy, shaky, and panicky ( $\alpha = .92$ ). PANAS and POMS items were rated on a 5-point scale ranging from (1) not at all to (5) extremely.

**EMA ED Behaviors**—As part of the EMA protocol, participants were instructed to report all eating episodes and to specify whether the episode was a snack, a meal, or a binge eating episode. Participants also reported each time they engaged in certain ED behaviors including self-induced vomiting, exercise, skipping a meal, and self-weighing.

## Statistical Analyses

A series of linear mixed models were used to examine the extent to which continuous affective variables (i.e., positive affect, negative affect, and tension/anxiety) varied across the course of the day, as well as across days of the week. Linear, quadratic, and cubic parameters were tested in each analysis. Models included a random intercept and a fixed effect for either hour of the day or day of the week, depending on the specific analysis. Given that the majority (~97%) of EMA reports were completed between 7 AM and 12 AM, only data collected within this time frame were used for the current analyses.

General estimating equations with a binomial logit link function were subsequently used to examine variation in the probability of a series of dichotomous ED behaviors (i.e., binge eating, vomiting, exercise, meal skipping, and self-weighing) across each hour of the day and each day of the week. For each time of day analysis, time was treated as a categorical variable with events grouped into 1-hour bins, producing 17 time categories (e.g., 7 AM to 7:59 AM, 8 AM to 8:59 AM, ... 11 PM to 11:59 PM).

## Results

### EMA Descriptives

Participants provided 14,482 separate EMA recordings during the waking hours of the day. Compliance with semi-random signals averaged 87% (range: 58–100%), and compliance for end of day recordings averaged 89% (range: 24–100%). With regard to the frequencies of ED behaviors in the two-week EMA protocol, the overall mean for each behavior across participants was as follows: binge eating =  $2.4 \pm 4.6$  episodes, vomiting =  $4.1 \pm 8.6$  episodes,

exercise =  $6.1 \pm 7.7$  episodes, meal skipping =  $7.0 \pm 8.0$  episodes, and self-weighing =  $4.6 \pm 6.8$  episodes.

### Time of Day

**Affective Experiences**—No statistically significant linear, quadratic, or cubic effects were found for time of day in relation to either positive affect or negative affect ( $ps > .05$ ), suggesting that there was not a discernable temporal pattern for positive and negative affective experiences across the course of the day. In contrast, a small but statistically significant positive linear effect was found for time of day in relation to tension/anxiety ( $F_{(1, 13848.3)} = 4.86, p = .028$ ); the quadratic and cubic effects were nonsignificant ( $ps > .05$ ). This finding suggests that overall, participants experienced a gradual, steady increase in tension/anxiety across the day.

**ED Behaviors**—Time of day was found to be significantly associated with the occurrence of each of the ED behaviors examined, including: binge eating ( $\chi^2_{(16)} = 82.48, p < .001$ ), vomiting ( $\chi^2_{(16)} = 102.51, p < .001$ ), exercise ( $\chi^2_{(16)} = 82.94, p < .001$ ), meal skipping ( $\chi^2_{(16)} = 142.85, p < .001$ ), and self-weighing ( $\chi^2_{(16)} = 112.93, p < .001$ ). Figure 1 depicts the frequency of each of the ED behaviors across the waking hours of the day (i.e., 7 AM to 12 AM). For binge eating, the 7 PM and 9 PM hours had the two highest frequencies, although smaller peaks were also present during the 11 AM and 4 PM hours. Fifty percent of all reported binge eating episodes occurred between 6 PM and 12 AM. A pattern similar to that of binge eating was found for vomiting, with the 7 PM and 9 PM hours exhibiting the two highest frequencies. Approximately half of all reported episodes of vomiting occurred between 6 PM and 12 AM. For exercise, the pattern was more widely distributed, with a primary peak during the 11 AM hour, and smaller secondary peaks at the 8 AM and 4 PM hours. Approximately one third of all reported episodes of exercise occurred between 7 AM and 12 PM. The pattern for meal skipping revealed three primary peaks at the 8 AM hour, the 11 AM hour, and the 1 PM hour. Approximately 40% of all reported episodes of meal skipping occurred between 7 AM and 12 PM. This pattern suggests a greater tendency to skip breakfast and lunch, and a lower frequency for skipping dinner. Finally, self-weighing behavior was found to predominately occur in the morning hours, with a peak at the 8 AM hour, and a little more than half of all episodes of self-weighing occurring between 7 AM and 12 PM.

### Day of Week

**Affective Experiences**—A significant effect was found for day of week in relation to positive affect ( $F_{(6, 13843.1)} = 14.59, p < .001$ ), indicating statistically significant variability in positive affect ratings across days of the week. An examination of the estimated marginal means revealed that the highest positive affect ratings were on Saturday ( $M = 18.96, SE = 0.48$ ) and the lowest were on Tuesday ( $M = 17.85, SE = 0.48$ ). A similar pattern was found for the association between day of week and both negative affect ( $F_{(6, 13842.6)} = 8.61, p < .001$ ) and tension/anxiety ( $F_{(6, 13842.7)} = 24.34, p < .001$ ). Based on the estimated marginal means, Tuesday was characterized by the highest levels of both negative affect ( $M = 18.76, SE = 0.69$ ) and tension/anxiety ( $M = 20.64, SE = 0.59$ ), while Sunday was characterized by

the lowest levels of negative affect ( $M = 17.91$ ,  $SE = 0.70$ ) and tension/anxiety ( $M = 19.35$ ,  $SE = 0.59$ ).

**ED Behaviors**—No significant effects were found for day of week in relation to the occurrence of binge eating ( $\chi^2_{(6)} = 4.61$ ,  $p = .595$ ), vomiting ( $\chi^2_{(6)} = 5.07$ ,  $p = .534$ ), exercise ( $\chi^2_{(6)} = 7.36$ ,  $p = .288$ ), meal skipping ( $\chi^2_{(6)} = 2.94$ ,  $p = .816$ ), or self-weighing ( $\chi^2_{(6)} = 8.18$ ,  $p = .225$ ).

## Discussion

The current study sought to build upon the existing literature regarding temporal features characterizing the occurrence of ED behaviors and affective experiences in AN. In particular, in comparison to the approach taken in prior studies using data from the current sample, this investigation focused on specifying the naturalistic timing of these events and experiences. The current findings may thus have utility both in identifying time periods of potentially elevated risk for ED behaviors in AN, as well as providing a broader context for understanding previous findings regarding affect-ED behavior associations in AN. With regard to affective experiences, there was not a significant association between time of day and the experience of positive and negative affect in AN, although there was a pattern of slightly increasing tension/anxiety across the day. Day of week effects were found to be significant for all of the affective variables, although overall differences between the days were small. Both negative affect and tension/anxiety were highest mid-week (Tuesday–Thursday) and lowest on the weekends, whereas positive affect was found to be lowest at the beginning of the week (Monday and Tuesday) and highest at the end of the week and beginning of the weekend (Friday and Saturday). Regarding ED behaviors, time of day was consistently found to be associated with their occurrence, although the nature of the association differed across behaviors. Findings revealed that both binge eating and vomiting were generally more likely to occur later in the day (i.e., in the late afternoon/evening). Temporal patterns for the other ED behaviors were more varied, with exercise and particularly self-weighing occurring more commonly in the morning and less commonly in the evening, and meal skipping most likely to occur at times corresponding to breakfast and lunch and less likely to occur around dinnertime. The occurrence of ED behaviors was not found to vary across days of the week.

In considering the current results, particularly given previous EMA research on affect and ED symptoms, several findings are worth noting. First, prior evidence has suggested an association between affective experiences and ED behaviors in AN, particularly in terms of the occurrence of ED behaviors following times of increasing negative affect [8]. Additionally, other evidence has suggested that the likelihood of certain ED behaviors may be higher at times corresponding to higher anxiety [9]. In the current study, however, ED behaviors varied by hour of the day, while negative and positive affect did not. Despite this apparent lack of correspondence between the timing of affect and ED behaviors in this study, it should be noted that evidence supports the existence of distinct patterns of daily affective experiences in AN [9]. Thus, whereas on average affect may not change substantially across the day, it may be the periods of greater affective variability that are most strongly associated with ED behaviors. This would also be consistent with a situation in which affect remains

relatively stable at most times, but is more highly variable around the occurrence of ED behaviors. Second, there may be utility in considering the current findings in light of results from a similar EMA study in BN [16]. A higher probability of binge eating and purging in the later hours of the day was found in both studies, as was a pattern in which negative affect was highest mid-week and lowest on the weekends. However, differences included the presence of significant variation in ED behaviors across days of the week in BN (i.e., binge eating and purging were most frequent on Sundays), as well as significant variation in negative affect (slightly increasing pattern) and positive affect (i.e., inverted U-shape trajectory) across hours of the day. Although the current findings do not address mechanisms underlying these differences, possible explanations include: (a) greater impact of situational factors on ED behavior occurrence in BN versus AN, which may be characterized by more habitual patterns of behavior, and/or (b) a greater propensity for emotional instability even outside of times surrounding ED behaviors in BN versus AN. Future research will be needed to test these hypotheses.

Although this investigation was exploratory, the current findings may inform theories of the etiology and/or maintenance of AN. For example, the apparent temporal differences in affective experiences and the occurrence of ED behaviors potentially highlights the relevance of momentary (versus dispositional) factors that may be important to the maintenance of AN symptoms over time. Further, these results may have potential clinical utility in terms of considering times at which, on average, individuals with AN may be at most risk for ED behaviors. For instance, the greater likelihood of binge eating and/or purging later in the day suggests that this is a time that patients who engage in one or both of these behaviors should be particularly aware of potential cues or triggers for such behaviors, as well as planning for ways of coping with urges that may arise. Further, the greater likelihood of skipping breakfast and lunch suggests the potential benefit of targeting those meals in particular in AN interventions, as well as adopting strategies to reduce potentially maladaptive habits of self-weighing in the morning hours. Relatedly, given prior evidence suggesting that higher negative affect and/or lower positive affect often precede ED behaviors, understanding the extent to which days of the week may differ in such affective experiences could provide guidance on planning for those risky periods. For example, although the current study did not find a difference in the occurrence of ED behaviors across days of the week, results indicating higher negative affect and lower positive affect on Tuesdays may suggest that this is a day of the week for which patients may want to be particularly aware of their emotions and any related urges/impulses to engage in ED behaviors. Ultimately, the current findings offer a broader context for understanding the general timing of ED behaviors and affective experiences in AN, providing some guidance and a potential starting point for clinicians seeking to understand the unique experience and timing of ED symptoms in patients with AN.

The current study should be interpreted in light of certain limitations. First, although the use of EMA in the current study is a strength in that it allowed for greater ecological validity, reduced retrospective recall biases, and likely provided a more accurate index of the frequencies of behaviors (versus global estimation) in a naturalistic setting, it is possible that participants did not report all instances of ED behaviors. Second, the sample was comprised of primarily Caucasian, adult women, thus the extent to which these findings would



generalize to adolescents and more ethnically diverse samples is unclear. Third, although the severity of AN symptoms varied across participants, the extent to which the current findings would apply to a more severe AN sample are unclear. Fourth, given evidence that AN may be characterized by disturbances in emotional functioning [4], difficulties related to emotional awareness or identification could have impacted responses to the affective items in the EMA protocol for some participants. Relatedly, it is possible that the process of participants providing repeated reports of affect and behavior in their natural environment impacted these experiences (i.e., reactivity), although existing evidence in the ED literature suggests that such EMA reactivity is limited [17]. Fifth, prior research has suggested that individual difference variables (e.g., personality) may impact associations between affective experiences and ED behaviors [18]. Although this was not addressed in the current study due to the goal of providing a broad description of the naturalistic timing of affect and ED behaviors in AN, it is an area that would benefit from further research. Finally, while there are logical interpretations of the current findings in terms of possible reasons for the differing occurrence of affective states and ED behaviors across hours of the day and days of the week, future research that includes more detailed questions about environmental context and that addresses more qualitative aspects of certain experiences in those with AN is needed.

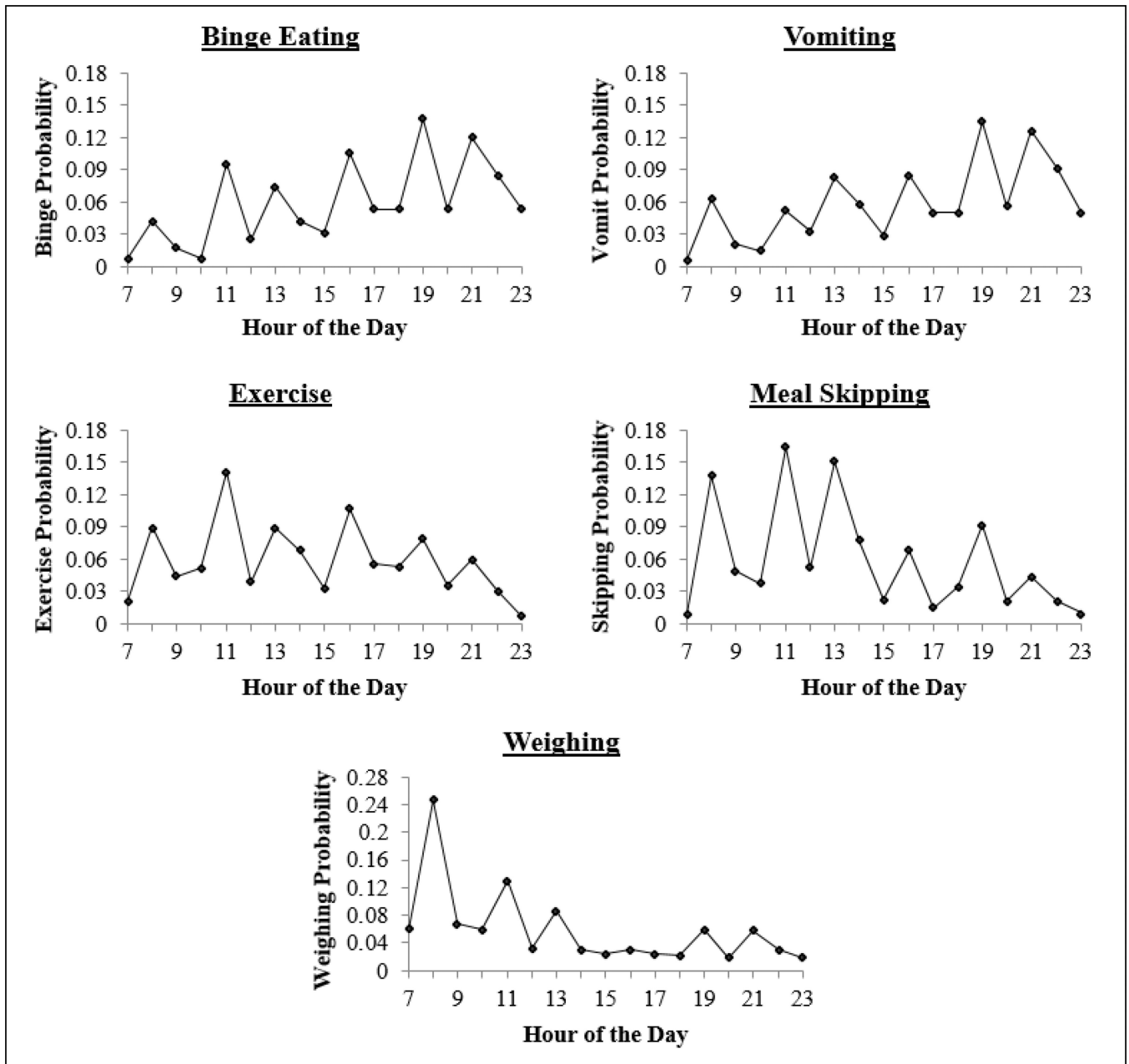
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**Figure 1.**  
Distribution of ED Behaviors across Hours of the Day.