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RESEARCH ARTICLE

Loss of control eating exhibits an evening diurnal shift among females with bulimia nervosa and binge-eating disorder

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Abstract

Loss of control (LOC) is a hallmark feature of binge eating that is associated with significant distress and impairment. Despite the central role diurnal rhythms may play in the development and maintenance of LOC eating, diurnal patterns of LOC remain understudied and poorly characterised. We assessed the diurnal timing of LOC in a sample of females with bulimia nervosa and binge-eating disorder who participated in a study assessing the impact of bright light exposure on binge eating, hypothesising that higher ratings of LOC would be more likely to occur later in the day. Participants ($N = 34$) completed a 22-day protocol during which they provided LOC ratings six times daily. Kernel density estimates describing LOC ratings across times of day were compared using permutation tests of equality. Results demonstrated an evening shift in LOC, wherein higher LOC was more likely to occur later in the day and lower LOC was more likely to occur earlier in the day. This study is the first to clearly depict the phenomenon that the likelihood of experiencing higher LOC increases throughout the day, pointing to the potential role diurnal rhythms, such as disrupted appetitive rhythms or mood variations, may play in maintaining binge eating.

KEYWORDS
binge eating, binge-eating disorder, bulimia nervosa, diurnal rhythm, loss of control

Highlights

- Females with bulimia nervosa and binge-eating disorder demonstrated an evening diurnal shift in loss of control (LOC) eating.
- Higher LOC was more likely to occur later in the day than lower LOC, and lower LOC was more likely to occur earlier in the day than higher LOC.
- This study is the first to clearly depict the phenomenon that the likelihood of experiencing higher LOC increases throughout the day.

1 | INTRODUCTION

Loss of control (LOC) over eating is a subjective experience considered a hallmark feature of binge eating that distinguishes binge eating from overeating (Rossiter & Agras, 1990; Walsh et al., 1989). Binge-eating episodes involve eating an objectively large amount of food in a discrete period of time while experiencing a sense of LOC over what or how much one eats (American Psychiatric Association [APA], 2022; Claudino et al., 2019). Binge eating is associated with a diurnal pattern of consuming more calories later in the day (Ellison et al., 2016; Harvey et al., 2011; Zendegui et al., 2014), a pattern cited by a recent model of binge eating that posits a central role for diurnal appetitive rhythms in the development and maintenance of binge eating (De Young & Bottera, 2022). Indeed, intervening on eating rhythms through the establishment of a regular pattern of eating decreases binge eating (Ellison et al., 2016; Fairburn, 2008; Zendegui et al., 2014). While diagnostic criteria for bulimia nervosa and binge-eating disorder necessitate recurrence of objective binge-eating episodes, in which individuals consume an objectively large quantity of food (e.g., >1200 kcal) accompanied by LOC (APA, 2022), individuals with eating disorders characterised by binge eating also endorse experiencing subjective binge-eating episodes wherein the quantity consumed is not objectively large despite the individual perceiving the quantity as such (e.g., Brownstone & Bardone-Cone, 2021; Kerzhnerman & Lowe, 2002). Importantly, despite LOC being a defining feature of binge-eating episodes, LOC can accompany consumption of any amount of food. In fact, some research supports that the quantity of food consumed during binge-eating episodes may be less clinically relevant than the experience of LOC (Goldschmidt et al., 2012; Keel et al., 2001; Latner et al., 2007; Mond et al., 2010; Pollert et al., 2013; Pratt et al., 1998; Sonneville et al., 2013). However, diurnal patterns of LOC remain understudied and poorly characterised. Because LOC is specifically associated with clinically significant distress and impairment and is a transdiagnostic feature of eating disorders (APA, 2022; Goldschmidt et al., 2012), better understanding patterns of LOC eating for individuals with eating disorders may illuminate their maintaining mechanisms and enhance real-time targeted interventions.

Examination of diurnal eating patterns among individuals with eating disorders provides critical insight into periods of potential behavioural vulnerability. Ecological momentary assessment (EMA) may be especially useful for examining the daily behavioural patterns of individuals with LOC eating. Smyth et al. (2009) used a 2-week EMA protocol to examine affect, stress, and the occurrence of binge-purge behaviours in women with bulimia nervosa. Although the authors primarily focused on the dichotomous presence or absence of binge-eating episodes involving the consumption of large quantities of food, their findings demonstrated that the likelihood of binge eating increased as the day progressed, peaking in the early afternoon and late evening (Smyth et al., 2009). Smyth et al. (2009) posited that the combination of accumulated daily stressors and increased negative affect across the day may contribute to greater likelihood of binge eating later in the day for women with bulimia nervosa. It is also possible that alterations in diurnal eating patterns (e.g., restriction earlier in the day) promotes later in the day binge eating. In fact, restricting caloric intake earlier in the day is associated with greater overall intake (de Castro, 2004), and evening shifted diurnal appetitive rhythms is associated with weight gain and eating disorder behaviours (i.e., binge eating, restriction; Bernardi et al., 2009). In their review, Bernardi et al. (2009) posit that evening shifted diurnal appetitive rhythms may ultimately lead to the development of eating disorders involving binge eating and nighttime eating (i.e., binge-eating disorder and night-eating syndrome), a notion consistent with the biobehavioral circadian model of restrictive eating and binge eating (De Young & Bottera, 2022). Further, extant findings demonstrate associations between both restriction and fasting and increased likelihood of same-day binge eating among individuals with anorexia nervosa and bulimia nervosa (De Young et al., 2014; Zunker et al., 2011). Similarly, individuals with binge-eating disorder who eat less than three meals daily, signalling an irregular eating pattern, report greater frequency of binge eating (Masheb & Grilo, 2006). Given the centrality of LOC to binge eating, the diurnal risk of binge eating likely represents a confluence of both consumption rhythms and LOC rhythms, underscoring the importance of characterising daily eating behaviours and associated degrees of LOC among individuals with eating disorders. A 1-week examination of naturalistic eating behaviours among individuals with binge-spectrum eating disorders demonstrated that, on days when it occurred, LOC eating was more likely to occur later in the day (Bottera & De Young, 2023). Interestingly, findings demonstrated that overall meal timing did not differ between days with and without LOC, suggesting that consistently irregular consumption rhythms may set the stage for momentary factors to prompt LOC eating (Bottera & De Young, 2023). Importantly, LOC was assessed dichotomously, limiting nuanced understanding of the underlying continuous latent construct. Further research specifically examining the time-of-day effect of LOC severity among individuals with eating disorders may aid

in a more complete transdiagnostic understanding of this phenomenon.

Although binge eating is conceptualised as a dichotomous event that is either absent or present (e.g., Greeno et al., 2000; Smyth et al., 2009; Wegner et al., 2002), LOC may be better understood as existing on a dimension wherein the higher someone's LOC, the greater their distress (Goldschmidt, 2017; Latner et al., 2014). Accordingly, extant EMA research has assessed LOC with ordered rating scales ranging from absence of LOC to extreme LOC (e.g., Berg et al., 2014; Goldschmidt et al., 2012). Results from one such study demonstrated that higher LOC is associated with higher negative affect prior to and following meals for individuals with binge-eating disorder (Goldschmidt et al., 2012). Characterising the extent to which individuals with eating disorders experience LOC while eating across various times of day may provide a richer sense of their diurnal eating patterns and risk for binge eating. Thus, we aimed to assess the diurnal timing of various degrees of LOC in a sample of females with bulimia nervosa and binge-eating disorder who participated in a study assessing the impact of bright light exposure on binge eating. Bright light exposure is a potent synchroniser of circadian rhythm entrainment and may have regulatory effects on both circadian and diurnal rhythms. Even so, we hypothesised a diurnal shift in eating behaviour dependent upon the degree of LOC, such that higher ratings of LOC would be more likely to occur later in the day.

2 | METHOD

2.1 | Participants

Females (i.e., assigned female sex-at-birth; $N = 34$; ≥18 years old; BMI ≥18.5 kg/m^2) with clinically significant binge eating (i.e., on average, ≥2 objectively-large binge-eating episodes/week over the previous 3 months), meeting diagnostic criteria for either bulimia nervosa or binge-eating disorder, were eligible to participate. Participants were ineligible if they: (a) were currently receiving psychotherapy; (b) had a change in psychotropic medication within 6 weeks of study enrolment; and/or (c) had any physical or mental conditions that might be adversely affected by the administration of bright light (e.g., bipolar disorder, diabetic retinopathy, macular degeneration). We recruited from a mountain west college town community through web-based postings and paper advertisements. Advertisements directed interested females who currently experienced binge eating to complete an online screening or call the laboratory for more information.

2.2 | Measures

2.2.1 | Clinical interview

Structured Clinical Interview for DSM-5

The Structured Clinical Interview for DSM-5 (SCID-5) (First, 2014) is a structured interview for mental disorders as classified by the Diagnostic and Statistical Manual of Mental Disorders, fifth Edition (*DSM-5*; APA, 2013). We used the SCID-5 to characterise the sample in terms of comorbid psychopathology at baseline. We also used the SCID-5 to gather demographic information.

Eating Disorder Examination

The Eating Disorder Examination (EDE) (Fairburn, 2008) is a structured interview of eating disorder psychopathology that was used to confirm eligibility and characterise eating disorders at baseline.

2.2.2 | Ecological momentary assessment

LOC ratings

Participants wore an Actiwatch Spectrum PRO® 24 h per day. Participants completed six signal-contingent ratings of LOC each day at semi-random times during participants' typical waking hours. Signals were tailored to participants to occur when they were awake based upon their reported sleep windows. All participants reported typical diurnal waketimes and nocturnal sleep times, and participants did not report shifted sleep-wake timing (e.g., shift-work sleep schedule). Participants were prompted with a vibration and sound alert to rate LOC experienced during any eating episodes that occurred since their last report. If they had not eaten since their last report, participants entered a rating of 0. If they had eaten, participants rated their degree of LOC (i.e., *Rate how in control you felt while eating*) from 1 (*feeling completely in control*) to 9 (*feeling completely out of control*). A similar single-item assessment of LOC was previously used in EMA research examining degrees of LOC (Goldschmidt et al., 2012). An off-wrist detector indicated whenever the device was not worn.

2.3 | Procedure

Study procedures were approved by the local Institutional Review Board. After an initial phone screening, individuals attended a baseline laboratory appointment during which they were provided with informed consent documents. Consenting participants underwent diagnostic clinical interviews to confirm eligibility and assess

clinical diagnoses and binge-eating frequency. Participants were oriented to the 22-day protocol, which began the subsequent day, and provided a reminder card with information on LOC ratings for reference. Across all 22 days, participants wore an Actiwatch Spectrum PRO®, on which they rated the degree of LOC experienced during eating episodes. As part of the parent study, participants also underwent a bright light exposure manipulation for which they received bright light exposure (~10,000 lux) and normal indoor light exposure (~500 lux) for half of the last 20 days of the 22-day protocol, randomised for order in which the exposures occurred. Participants received both normal and bright light exposure during their participation using a Ultralux® V HD-LED lamp for 30 min starting at 30 min post-waking. For example, participants randomised to first receive the bright light condition were instructed to initiate use of the light lamp set to produce approximately 10,000 lux at 22-inches (i.e., participants were to sit approximately 22 inches from the lamp) from day 3 through day 12, exchange their bright light lamp for an identical lamp set to produce approximately 500 lux, and use the dimmer lamp from day 13 through day 22. Adherence to use of the light lamps was confirmed based on ambient light readings on the Actiwatch Spectrum PRO®. Participants received compensation dependent on their degree of protocol adherence, including $50 USD for completing the baseline laboratory visit, $2 USD per day for wearing the Actiwatch Spectrum PRO® for a minimum of 22 h, and $0.50 USD per LOC rating.

2.4 | Data analysis

Each LOC rating (from 1 to 9) was paired with the time at which the rating was made; both were recorded by the Actiwatch Spectrum PRO®. These paired data points of LOC ratings by time were analysed using kernel density estimates. Kernel density estimates reflect the probability of an event occurring at each unit of the *x*-axis, given that it occurs. They are particularly useful for estimating the continuous distribution of a phenomenon that is measured discretely and comparing the distribution to other distributions (e.g., to examine departures from normality or to identify areas of two distributions that differ from one another). In our use, the probabilities (*y*-axis) reflect the probability of an eating episode with a specific LOC rating occurring at each hour of the day on days when an eating episode of that rating occurs. Thus, the cumulative probability across the *x*-axis is equal to 1. As a result, comparisons between multiple distributions reflect relative risk rather than absolute risk. Kernel densities for all ratings individually were estimated first. Then, to limit the number of pairwise comparisons, three groups of LOC ratings were formed: low (1–3); moderate (4–6); and high (7–9). Each group was compared to the others pairwise using parametric tests of equality, as performed by the sm package (version 2.2–5.7; Bowman & Azzalini, 2021) in R (v4.2.1; R Core Team, 2022). The normal optimal smoothing parameter was applied, the mean of which is used for both distributions being compared. The permutation tests were performed using 10,000 samples with replacement, without regard to group assignment, to quantify the likelihood of observing a pair of distributions differing as much or more than the two distributions observed. Finally, a region of equality was computed at 200 points along the *x*-axis. Where density estimates enter the region indicates times of day at which the probabilities for the two groups being compared do not significantly differ.

As the parent study involved a within-subjects bright light exposure manipulation, we examined potential effects of the manipulation to determine appropriateness of collapsing data across conditions for planned analyses. While all participants received the bright light intervention, the order in which they received bright light was randomised, creating two conditions in addition to the baseline period wherein participants did not use the light at any level. We compared density distributions across conditions (i.e., baseline, normal light [~500 lux], and bright light [~10,000 lux]) at each level of LOC (i.e., low, moderate, and high) using the same parametric tests of equality.

3 | RESULTS

There were no significant differences between density distributions across conditions ($p = 0.118–0.890$), thus we combined conditions for our planned analyses.

Participant demographics and diagnostic information are displayed in Table 1. There were 4268 momentary signals. Of these, 309 (7.2%) were missing ratings of LOC, resulting in 3959 total valid LOC ratings across 34 participants. The distribution of valid LOC values demonstrated adequate representation across the range of values, and LOC groups were well represented (see Table 2 for complete distribution). Further protocol adherence, as determined by the Actiwatch Spectrum PRO® off-wrist detector, was excellent. The mean minutes per day of off-wrist time was 79.67 (SD = 108.35; median = 17.17), and over 90% of participants averaged under 120 min per day of off-wrist time, which was consistent with instructions provided to participants.

Consistent with our hypothesis, findings demonstrated an evening diurnal shift in eating behaviour

TABLE 1 Participant demographics and diagnostic information.

Participant demographics ($N = 34$)		***n* (%)**
Racial identity		
White		29 (85.29)
Asian		1 (2.94)
Black		1 (2.94)
Other		2 (5.88)
Missing		1 (2.94)
Ethnic identity		
Hispanic		7 (20.59)
Non-hispanic		26 (76.47)
Missing		1 (2.94)
	M (SD)	**Range**
Age (years)	31.06 (11.75)	19–64
BMI (kg/m^2)	31.53 (7.32)	19.53–45.42
BMI classifications		***n* (%)**
Normal weight (18.5–24.9 kg/m^2)		8 (23.53)
Overweight (25.0–29.9 kg/m^2)		11 (32.35)
Obese (>30 kg/m^2)		15 (44.12)

***DSM-5* disorders ($N = 34$)**	**Current *n* (%)**	**Lifetime *n* (%)**
Depressive disorders	12 (35.29)	28 (82.35)
Major depressive disorder	7 (20.59)	25 (73.53)
Persistent depressive disorder	3 (8.82)	6 (17.65)
Premenstrual dysphoric disorder	4 (11.76)	4 (11.76)
Substance use disorders	4 (11.76)	13 (38.24)
Alcohol	3 (8.82)	11 (32.35)
Sedative-hypnotic-anxiolytic	0 (0)	1 (2.94)
Cannabis	3 (8.82)	5 (14.71)
Stimulants/cocaine	0 (0)	3 (8.82)
Hallucinogens	0 (0)	2 (5.88)
Inhalants	0 (0)	1 (2.94)
Anxiety disorders	22 (64.71)	24 (70.59)
Panic disorder	1 (2.94)	2 (5.88)
Agoraphobia	1 (2.94)	1 (2.94)
Social anxiety disorder	14 (41.18)	16 (47.06)
Specific phobia	7 (20.59)	7 (20.59)
Generalized anxiety disorder	10 (29.41)	11 (32.35)
Other specified anxiety disorder	2 (5.88)	2 (5.88)
Obsessive-compulsive disorder	1 (2.94)	1 (2.94)
Eating disorders	34 (100.00)	34 (100.00)
Anorexia nervosa	0 (0)	1 (2.94)
Bulimia nervosa	5 (14.71)	10 (29.41)
Binge-eating disorder	29 (85.29)	29 (85.29)
Trauma- and stressor-related disorders	7 (20.59)	12 (35.29)
Posttraumatic stress disorder	6 (17.65)	11 (32.35)
Other specified trauma- and stressor-related disorder	1 (2.94)	2 (5.88)

EDE binge-eating episodes	**28-day M (SD), range**	**Month 2 M (SD), range**	**Month 3 M (SD), range**
Objective binge-eating episodes	16.21 (7.17), 6–34	15.53 (8.59), 2–36	14.68 (7.63), 2–33
Subjective binge-eating episodes	3.65 (9.63), 0–44	4.38 (10.26), 0–44	3.79 (9.85), 0–44

Note: Participant demographics assessed during diagnostic interview. BMI—body mass index. *DSM-5*—Diagnostic and Statistical Manual of Mental Disorders, fifth Edition. *DSM-5* diagnoses obtained via the Structured Clinical Interview for DSM-5 Disorders (SCID-5). Participants could meet diagnostic criteria for more than one depressive disorder, substance use disorder, anxiety disorder, and trauma-and stressor-related disorder (lifetime or current). Participants could meet diagnostic criteria for more than one lifetime eating disorder. No participants endorsed present or past frequency of Bipolar and Related Disorders or Schizophrenia and Other Psychotic Disorders. EDE—Eating Disorder Examination. Objective and subjective binge-eating frequency was derived at baseline for the past 3 months individually.

among females with bulimia nervosa and binge-eating disorder, such that, when it occurred, higher LOC was more likely to occur later in the day than earlier in the day. Figure 1 depicts density estimates at each individual degree of LOC. Low, moderate, and high LOC density distributions all significantly differed from one another, supporting the evening diurnal shift (all p's < 0.0001; Figure 2). Density distributions depict the likelihood of low, moderate, or high LOC ratings occurring throughout the day and the times at which these probabilities differ from one another. When they occurred, moderate LOC ratings were most likely to occur at approximately 3 and 8 PM and were 1.5 times as likely to occur as low LOC at 8 PM. When they occurred, high LOC ratings were most likely to occur at approximately 8 PM and were twice as likely to occur as low LOC ratings at that time; conversely, high LOC ratings were less than half as likely to occur as low LOC ratings at 10 AM. Finally, while both moderate and high LOC ratings were likely to occur at approximately 8 PM, moderate LOC ratings were nearly

half as likely to occur as high LOC ratings at that time, and high LOC ratings were nearly half as likely as moderate LOC ratings at 10 AM.

4 | DISCUSSION

We aimed to characterise the extent to which individuals with clinically significant binge eating experience LOC while eating over the course of the day to inform on potential maintenance factors that may be targets of treatment. Our results confirmed the presence of a significant evening diurnal shift for LOC eating episodes, such that individuals were more likely to experience elevated levels of LOC later in the day than earlier in the day. Further, the degree to which females with binge eating experienced LOC differed according to the time of day; that is, moderate and high levels of LOC were more likely than low levels of LOC to occur during later eating episodes, and low levels of LOC were more likely to occur during earlier eating episodes. These results suggest that the risk for LOC eating demonstrates a diurnal shift wherein the likelihood of experiencing higher LOC increases throughout the day while the likelihood of experiencing lower degrees of LOC is greater earlier in the day.

Results should be interpreted in the context of the following limitations. First, degrees of LOC were assessed during an experiment that occurred in participants' natural environments in which participants were exposed to both bright light (~10,000 lux) and normal light (~500 lux). Despite no significant differences between conditions at low, moderate, and high levels of LOC, it is possible that the manipulation (i.e., exposure to regular morning light) had unknown effects on our observations. However, to date, ours is the most detailed assessment of this phenomenon available, and we would not expect that the effect of the intervention would create the observed patterns; rather, without the light intervention, the diurnal shift of LOC may be more exaggerated than what our data suggests, as bright light exposure may regulate these diurnal rhythms (Beauchamp & Lundgren, 2016; Pail et al., 2011). Future research should examine this phenomenon both in a naturalistic environment and throughout the course of treatment to assess how the diurnal rhythms of LOC shift from pre-treatment to post-treatment. Second, our sample includes only females, limiting our generalisability to males and necessitating continued assessment of diurnal patterns of LOC in males, especially given comparable rates of LOC eating in males (Hudson et al., 2007). Third, although all degrees of LOC were represented in our data, we elected to group ratings in low, moderate, and high LOC categories to limit the number of comparisons. These groupings were formed for the purpose of comparing across degrees of LOC; however, low, moderate, and high LOC categories were formed arbitrarily, with 3 degrees of LOC represented in each. While this is a critical step towards nuanced assessment of the underlying continuous latent dimension and is analogous to approaches taken by others (e.g., Goldschmidt, 2017; Latner et al., 2014), a longer period of assessment with a greater sample size may provide the opportunity to examine more detailed information regarding each distinct degree of LOC. Fourth, our single-item LOC assessment lacks psychometric validation, though it is similar to those used in other studies. Developing momentary LOC measures that accurately capture an individual's standing on the latent construct is not altogether an easy task. In fact, scales used to assess past-month LOC eating are limited in their ability to discriminate between adults with and without eating disorders (e.g., Blomquist et al., 2014; Latner et al., 2014). Even so, approximating degrees of LOC with a single item among individuals with eating disorders characterised by binge eating reduced participant burden in our study, especially given the frequency and duration with which participants were asked to rate their degree of LOC (i.e., 6 times daily for 22 days). Given the importance of examining momentary LOC, future research should develop and validate a LOC measure for use in EMA research and clinical tracking. Finally, all demographic variables were assessed during the SCID-5 diagnostic interview, limiting our assessment of

TABLE 2 LOC rating distribution.

LOC ratings ($N = 3959$)	Individual ratings *n* (%)	Grouped ratings	*n* (%)
0 (not eaten since last report)	1573 (39.7)	–	–
1 (no LOC)	776 (19.6)	Low	1506 (38.0)
2	430 (10.9)		
3	300 (7.6)		
4	227 (5.7)	Moderate	610 (15.4)
5	228 (5.8)		
6	155 (3.9)		
7	116 (2.9)	High	270 (6.8)
8	71 (1.8)		
9 (total LOC)	83 (2.1)		

Note: Individual LOC ratings were grouped into low (1–3), moderate (4–6) and high (7–9) categories for comparative analyses.

Abbreviation: LOC, loss of control.

potentially important demographic variables, including gender identity and sexual orientation.

Overall, our findings confirm the presence of a clear evening diurnal shift in LOC eating for females with binge eating. These results are consistent with the proposed role of diurnal rhythms in maintaining binge eating (De Young & Bottera, 2022), such that the delayed diurnal appetitive rhythms observed among those with binge eating—both in quantity consumed (Ellison et al., 2016; Zendegui et al., 2014) and degrees of LOC experienced—likely increase risk for binge eating over the course of the day. In fact, our results extend existing findings implicating diurnal rhythm variations in risk for binge eating. Aligned with previous findings implicating the cumulative impact of daily stressors and negative affect on risk for binge eating (Smyth et al., 2009), our results indicate that risk for LOC increases over the course of the day across degrees of LOC, with low LOC eating episodes demonstrating an inverse diurnal pattern to high LOC eating episodes. The degree to which an individual experiences LOC may be dependent upon a host of factors, such as diurnal shifts in mood and appetite (e.g., hunger, satiety), which accumulate throughout the day and set the stage for binge eating. As posited in the biobehavioral circadian model of restrictive eating and binge eating (De Young & Bottera, 2022), acute, chronic, and/or phasic environmental disruptions (i.e., zeitgeber disruptions [e.g., travel, school stress, socialisation]) may prompt or worsen diurnal appetitive disruptions through their impact on circadian rhythm entrainment. Future research examining the potential role such disruptions have on LOC severity is warranted. Further, given the temporal relations identified between restriction and binge eating (e.g., De Young et al., 2014; Masheb & Grilo, 2006; Zunker et al., 2011), future research assessing the diurnal rhythms of restriction and their interplay with LOC may provide more detailed information regarding risk for binge eating.

Our study is the first to clearly depict the phenomenon that the likelihood of experiencing higher LOC increases throughout the day, underscoring the central role diurnal rhythms may play in binge eating. Such understanding sets a critical foundation for future studies

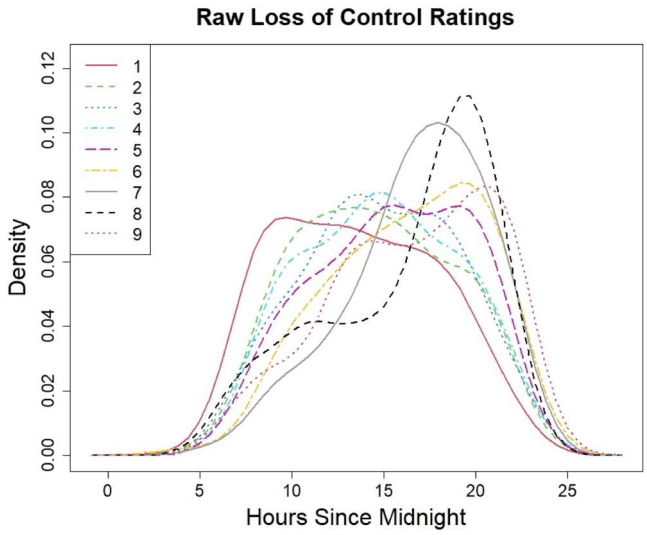

FIGURE 1 Kernel density of raw loss of control (LOC) ratings. *Note*: LOC was rated from 1 (*no LOC*) to 9 (*total LOC*) and each rating was paired with the time at which the rating was made. Kernel densities for all ratings were individually estimated and reflect the probability (*y*-axis) of an eating episode with a specific LOC rating occurring at each hour of the day (*x*-axis; hours since midnight) on days when an eating episode of that rating occurs.

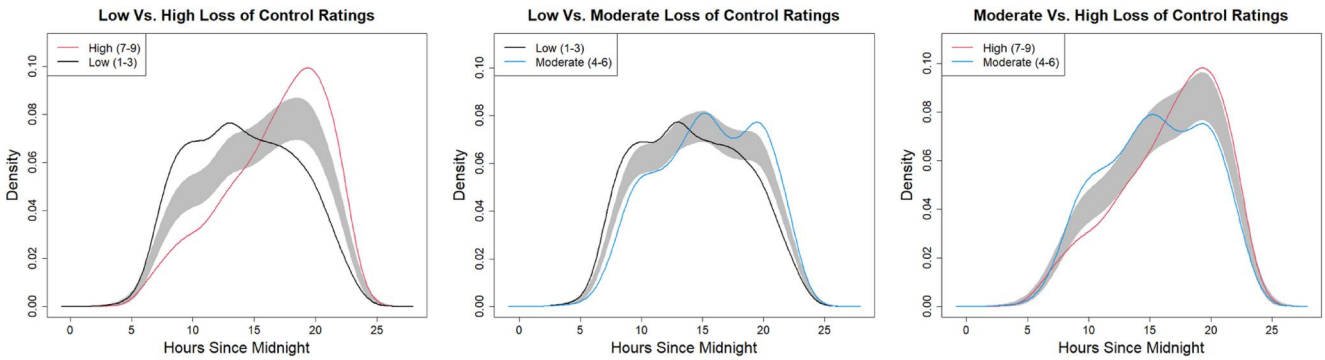

FIGURE 2 Comparison of low, moderate, and high loss of control (LOC) density distributions. *Note*: LOC was rated from 1 (*no LOC*) to 9 (*total LOC*) and each rating was paired with the time at which the rating was made. Kernel densities for all ratings were individually estimated and reflect the probability (*y*-axis) of an eating episode with a specific LOC rating occurring at each hour of the day (*x*-axis; hours since midnight) on days when an eating episode of that rating occurs. Figure lines depict three groups of LOC ratings: low (black; 1–3); moderate (blue; 4–6); and high (red; 7–9), which were compared using parametric tests of equality. Grey shaded regions represent the region of equality. Where density estimates enter the region indicates times of day at which the probabilities for the two groups being compared do not significantly differ. All p's < 0.0001.

examining the efficacy of targeted interventions aimed at reducing LOC eating and binge eating via potential explanatory mechanisms (e.g., diurnal mood variations, executive function changes, social rhythms, appetitive rhythms). Identifying patterns of LOC in patients would allow for a more personalised understanding of risk for LOC eating and proactive problem solving for at-risk time periods. Given the distress associated with LOC (Goldschmidt et al., 2012), focusing specifically on the reduction of LOC at the outset of treatment may predict early treatment response. For example, since vulnerability for higher LOC increases throughout the course of the day, an adjunctive intervention that focuses on: (a) identifying the possible mechanisms of the evening diurnal shift in LOC eating (e.g., diurnal mood variations), and (b) intervening directly on such maintaining mechanisms (e.g., behavioural activation activities scheduled throughout the day) may prove effective for reducing binge eating above and beyond establishing a regular pattern of eating. Further, tracking LOC with nuance that reflects the latent dimension at the outset of treatment (e.g., asking patients to provide ratings of the degree of LOC experienced on food logs separate from whether the eating episode was considered a binge-eating episode) may provide more comprehensive information pertinent to case conceptualisation for treatment planning. By assessing degrees of LOC in addition to discrete occurrences of binge eating, providers may be better equipped to identify the presence of evening diurnal shifts and when individuals begin to experience increases in LOC. When only assessing presence or absence of binge eating, as is typical practice with treatment food logs (Fairburn, 2008), providers and patients may be missing critical information regarding LOC throughout other eating episodes; that is, patients may be less likely to report that they experienced a binge-eating episode during eating episodes in which they experienced moderate levels of LOC compared to total LOC. For example, an individual may experience lower LOC after breaking a food rule relative to during a binge-eating episode, and the presence of lower LOC may provide critical information about the impact of breaking food rules on future risk of binge eating. Therefore, current food logs may neglect to capture diurnal variations in LOC that may, in combination with other diurnal rhythms, increase risk for binge eating. Further, changes in degrees of LOC across treatment may reflect changes in severity of binge eating even when binge eating still occurs. Thus, identifying patterns of LOC in patients would allow for a more personalised understanding of risk for binge eating, proactive problem solving for at-risk time periods, and changes in severity of eating disorder behaviours across treatment.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from author KPD (kyle.deyoung@uwyo.edu) upon reasonable request.

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