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Typology of eating episodes in children and adolescents with overweight/obesity

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Abstract

Background: Research suggests that youth with overweight/obesity can be subtyped according to disinhibited eating tendencies. No research has attempted to subtype classes of eating episodes along sensational, psychological, and hedonic dimensions.

Methods: Youth (*N*=39; 55% female) aged 8–14y with overweight/obesity completed a 2-week ecological momentary assessment protocol in which they reported on all eating episodes and their sensational, environmental, affective, and interpersonal contexts. Latent profile analysis (LPA) was used to classify episodes based on loss of control (LOC) while eating, self-reported overeating, food palatability, hunger, and cravings. Classes were compared on affective, interpersonal, appearance-related, and environmental correlates using Wald chi-square tests.

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Contributors

ABG and AHM conceived of and received funding for the study. ABG and AHM conceptualized the aims and hypotheses for the secondary data analysis presented in this paper. TBM and KES conducted the statistical analyses. SGE consulted on the design of the study and interpretation of findings. All authors were involved in writing the paper and had final approval of the submitted and published versions.

Conflicts of Interest

ABG has consulted for Sunovion Pharmaceuticals. None of the other authors have any conflicts of interest to declare.

Results: LPA identified three classes of eating episodes involving high levels of LOC/self-reported overeating ("binge-like" class), low levels of hunger ("eating-in-the-absence-of-hunger" class), and high hunger and cravings ("appetitive eating" class). Binge-like eating was associated with the highest levels of body dissatisfaction, interpersonal distress, and positive affect, and was most likely to occur in the after-school hours.

Conclusions: Binge-like eating tends to occur in a psychological context relative to other types of eating episodes in youth with overweight/obesity. Future research should explore whether certain classes of eating episodes are associated with distinct weight trajectories over time.

Keywords

Ecological momentary assessment; loss of control; overeating; hedonic; eating in the absence of hunger; obesity

1. Introduction

Pediatric overweight/obesity affect >30% of youth [1] and lead to physical and psychosocial disability [2, 3], with evidence of racial/ethnic disparities in prevalence and comorbidities [4]. Although overweight/obesity are multifactorial conditions, excess energy intake is a major determinant of weight status/regulation across the lifespan [5]. Yet, multiple intra- and extra-personal factors promote excess energy intake at a given eating episode or throughout a day, week, month, and beyond. These factors are rarely studied using momentary, naturalistic designs in youth [6], particularly those from underrepresented backgrounds, and overlap among factors is under-explored. Understanding contexts in which excess energy ingestion is likely could assist in developing novel, targeted interventions to improve eating and weight regulation in youth.

In the most basic sense, eating behavior is driven by homeostatic energy needs, mediated by metabolic (e.g., glucose depletion), hormonal (e.g., ghrelin/leptin signaling) and neural pathways [e.g., hypothalamic hunger signals; 7]. Yet, multiple environmental and psychological factors determine energy intake [5] and may drive eating in the absence of hunger (EAH, traditionally conceptualized via laboratory assessment of energy ingestion following eating to satiation [8], and more recently via momentary, naturalistic designs [9, 10]), binge and loss of control (LOC) eating [characterized by a lack of control over what/how much one is eating, with or without ingestion of a large amount of food, i.e., overeating; 11], and hedonic eating (eating driven by motivational or reinforcing properties of food, such as cravings [12] and/or perceived palatability of food [13]). These factors may overlap to some extent [14, 15], may occur independently or interactively in relation to eating episodes parameters (e.g., timing/duration, content), and in some cases differ across racial/ethnic dimensions [e.g., 16]. Little research has characterized momentary dimensions of eating episodes, and their confluence and correlates, in youth with overweight/obesity [17], who are vulnerable to eating behavior that is not determined solely by energy deficit needs [11].

In addition to characterizing real-time, naturalistic eating episodes, a clearer understanding of the environmental and psychological context in which these episodes occur could help

identify targets and optimal timing of momentary interventions. Hunger and cravings in adults tends to coincide with lunch and dinner [18], while overeating and LOC eating are more likely to occur during evening hours in both adults and children [19–21]. Furthermore, overeating is more likely to co-occur with environmental and social cues, such as being away from home [22] and being around others [23, 24], particularly for Black youth [25], while LOC eating tends to occur in secret/while alone [21]. Although adult research supports an association between negative affect and LOC eating [26], the pediatric literature is inconsistent [21, 24, 27, 28]. However, body dissatisfaction and interpersonal distress may contribute to LOC eating or overeating in predominantly Black pediatric samples [24, 28].

This study utilized latent profile analysis (LPA) to identify naturalistically occurring eating episode subtypes, and assessed their environmental and psychosocial features, among racially and ethnically diverse youth with overweight/obesity. LPA is an atheoretical classification approach which is typically used to classify subtypes of *individuals*, but has been used to classify subtypes of *eating episodes* in other populations with aberrant eating [29]. Based on the previous literature [5], we aimed to characterize eating episodes along sensational (i.e., hunger), appetitive (i.e., food palatability, cravings), and psychological dimensions (i.e., LOC, overeating). However, because LPA is data driven, we had no specific hypotheses about the types of eating episodes that would be classified or their unique combinations of features. In terms of correlates, we expected that episodes involving higher levels of LOC and/or overeating (independently or interactively) would be associated with momentary psychological correlates, while those involving higher levels of hunger, cravings, and/or food palatability (independently or interactively) would be associated with environmental features. However, we also anticipated that unique combinations of eating-related indicators (e.g., high LOC accompanied by low cravings) could demonstrate unexpected associations with psychosocial and environmental correlates. Therefore, despite being informed by a large body of research on independent determinants of eating behavior [5], this study was largely exploratory in its novel approach to understanding naturalistic eating episodes and their contextual correlates.

2. Materials and Methods

2.1. Participants and Procedures

Participants between 8–14y with overweight/obesity [body mass index (BMI)≥85th age- and sex-adjusted percentile; 30] were recruited from The University of Chicago Medicine and Illinois Institute of Technology, both of which provided ethical approval. Recruitment involved community advertisements, pediatrician referrals, and phone logs from previous studies where families agreed to be re-contacted [31]. Exclusion criteria included: medical conditions or medications influencing weight or appetite; eating disorder other than binge eating disorder (BED); inability to read/understand English fluently; and concurrent participation in obesity treatment. Caregivers of interested individuals were phone screened to assess basic inclusion/exclusion criteria, and eligible participants were invited with caregivers to attend a baseline study visit. A total of 94 families contacted the research team to learn about the study, of whom 11 were uninterested in being screened, and 83 were screened via phone. Of these 83 families, 44 presented for a baseline evaluation.

The remaining 39 either lost contact or failed to attend the evaluation (n=13; 33.3%), were uninterested/unavailable (n=11; 28.2%), did not meet inclusion criteria due to age, weight status, or medical/psychiatric conditions (n=4; 10.3%), or were not evaluated in person for unknown reasons (n=11; 28.2%). Of the 44 families completing a baseline evaluation, 39 met inclusion criteria and provided adequate EMA data (e.g., at least 1 week of EMA recording) to be included in the current analyses. The 44 excluded youth did not differ from the 39 who were included on gender (p=.98) or age (p=.87). After providing written informed assent/consent, participants had height and weight measured and completed assesments of eating behavior and psychosocial functioning. Participants and caregivers were then trained to complete EMA recordings.

The EMA protocol was administered through the ReTAINE platform (**RE**al **T**ime **A**ssessment **I**n the **N**atural **E**nvironment) using a secure link delivered to children's mobile device which provided access to surveys on ReTAINE's webpage. Surveys were meant to be completed independently via mobile device, but some children may have had assistance from caregivers, or completed surveys on a non-study device (e.g., desktop computer). All items were appropriate for a 3rd grade reading level. Participants were instructed to complete recordings after any eating episodes (event-contingent); before bedtime (interval-contingent); and at 3–5 semi-random times throughout the day [signal-contingent; 32]. Signaled prompts occurred every 2–3 hours between 8:00am-9:00pm on weekends, and 7:00–8:00am, 3:00–4:00pm, and 6:00–7:00pm on weekdays to avoid coinciding with school. Recordings were automatically time-stamped. During all recordings, participants were instructed to report on current affect, interpersonal events, weight-/shape-related concerns, and characteristics of any recent eating episode that had not been reported during prior recordings. This combination of signal-, event-, and interval-contingent recordings has been successfully implemented in prior EMA studies of youth with overweight [27, 28].

Children were required to complete a 1-day trial with ≥70% compliance to initiate the 14-day EMA study period; these data were not used in statistical analyses to reduce concerns about reactivity. Research staff contacted participants by phone after the first day of EMA recording, and every 2–3 days thereafter, to discuss compliance rates and address questions or concerns regarding assessment procedures.

Upon completion of the daily assessment phase, participants returned to the original research institution to return loaner Smartphones (if applicable); complete a brief, final assessment; and receive a final incentive payment. Participants received $50 for the initial evaluation; $50 for completing the 2-week protocol; and $1 for each response for up to $50 total (50 semi-random signals over the 2-week protocol).

2.2. Measures

2.2.1. Baseline measures.—

Height and weight were measured in light indoor clothing by trained staff via stadiometer and calibrated digital scale, respectively. Children's standardized body mass index (kg/m^2; z-BMI) was calculated using Centers for Disease Control and Prevention (CDC) growth charts [30]. Demographic data included children's age, gender, race/ethnicity, current medications, and medical problems.

2.2.2. Eating episode indicators.—At eating episode recordings, participants reported on several features of the episode. For this small exploratory study (the first of its kind in a heterogeneous sample of youth with overweight/obesity), we adapted existing, validated measures [Child Eating Disorder Examination (Child EDE); 33] drawn from previous EMA studies of youth [28] to develop our momentary items assessing LOC and overeating. Ratings for self-reported overeating ("To what extent do you feel that you overate?") and LOC ("While you were eating, did you feel… a sense of loss of control? … that you could not stop eating once you had started? … like you could not resist eating? … like a car without brakes, you just kept eating and eating?") were made on a 1- to 5-point Likert-type scale (1="no, not at all," and 5="yes, extremely"). The four LOC items were averaged to form a composite score based on high internal consistency (α=.91). Cravings and hunger levels ("Please rate how much you agree with the following statement: I am craving food" and "I am hungry," respectively) both were rated on a 1- to 5-point Likert-type scale (1="disagree strongly," and 5="agree strongly"), while food palatability was rated on a 10-point scale ("On a scale of 1 [terrible] to 10 [the best thing you have ever tasted] how good did the food you ate taste?"). Hunger and craving ratings were lagged to represent pre-episode scores (i.e., ratings were drawn from a separate EMA survey occuring closest in time prior to that in which the eating episode was reported).

2.2.3. Eating episode validators.—Across all EMA signal types, if participants reported that an eating episode had occurred since the last prompt, they then reported on the type of episode they experienced (meal, snack, or binge). Environmental variables included location (home, car, school, cafeteria, restaurant, outside, friend's house, other), and presence of dining companions ("Did you eat alone/with other people?"). Time of day when eating occurred included morning (0000h–1159h), afternoon (1200h–1659h), and evening (1700h–2359h). The PANAS [34] was used to measure mood state. The PANAS is a brief, reliable, and valid measure [35] that has been used in several EMA studies [36, 37], including studies involving children [27, 28]. Each affect item (e.g., distressed, excited) was rated on a 5-point scale ("1"="Not at all"; "5"="Extremely") and summed to form composite negative affect and positive affect scales (range=0–50). Shape/weight concerns were measured using five items adapted from the Child EDE that assessed feelings of fatness, dissatisfaction with shape/weight, and discomfort with shape/weight via a 7-point Likert-type scale ranging from "Not at all" to "Very much." Items were summed into a single scale (range=5–35) based on high internal consistency (α=.94). The Social Adjustment Scale-Self Report [SAS-SR; 38] was used to assess interpersonal context. Five items assessing loneliness, social rejection, friendship quality, and recent arguments, all rated on a 5-point scale ranging from "Not at all" to "A lot," were combined into a single scale (range=5–25) based on high internal consistency (α=.74).

2.3. Statistical Analyses

LPA was used to identify eating episodes classes using indicator variables (self-reported overeating severity, LOC severity, perceived palatability of food being consumed, and pre-episode craving and hunger), accounting for clustering of data by participant. Missing data were handled via full information maximum-likelihood. The best-fitting model was determined using the log-likelihood (LL), Akaike information criterion (AIC), Bayesian

information criterion (BIC), sample-size adjusted BIC (aBIC), and entropy. Lower BIC, AIC, and aBIC indicate better fitting models [39–41] and higher entropy values indicate better classification accuracy [42]. After determining the number of classes, multinomial logistic regressions were used to compare eating episode classes on episode type (meal, snack, binge, or other) and signal type (event-, signal-, or interval-contingent). The modified Bolck, Croon, & Hagenaar (BCH) method [43, 44] was used to compare classes on validator variables (negative and positive affect, body dissatisfaction, interpersonal problems, being alone versus not, being at home versus not, and time of day. This method remedies biases in the identifying latent class variables [43, 44]. Overall comparisons between episode classes and EMA-measured validators were conducted using Wald chi-square tests. Mplus 7 and SPSS 25 were used for analyses.

3. Results

Participants were 39 youth [*n*=22 females (56.4%); *M* age=11.2±1.9y] with overweight/obesity (*M* z-BMI=2.06±0.49; range=1.15–2.89) who self-identified as African-American (64.1%; *n*=25), Hispanic (15.4%; *n*=6), non-Hispanic Caucasian (15.4%; *n*=6), or Asian (2.6%; *n*=1), or did not report race/ethnicity (*n*=1), reflecting the demographics of the study location. Participants completed 13.83 (SD=1.74) days of EMA recordings, on average, including 1,119 (67.6%) signal-contingent, 151 (9.1%) event-contingent, and 387 (23.3%) bedtime recordings. There were 689 distinct eating episodes included in LPA, of which 419 were reported at signal-contingent recordings (60.8%), 123 at interval-contingent recordings (17.9%), and 147 at event-contingent recordings (21.3%). Children reported an average of 1.89±1.15 eating episodes per day, with most reported as meals (*n*=545; 79.1%) or snacks (*n*=118; 17.1%); one episode was labeled a binge (0.2%) and 25 were labeled “other” (3.6%). A 4-class solution displayed the best fit with the lowest values on model fit statistics (see Table 1). However, two of the classes in the 4-class solution had <5% of the sample within the class. Thus, we selected the 3-class solution for stability and ability to test for differences on validators, which is what we report on in the following text. The 3-class solution included: 1) eating in the absence of hunger (EAH; 83%; *n*=574), characterized by low scores on self-reported overeating severity, LOC severity, hunger, and cravings, and moderate scores on food palatability; 2) appetitive eating (8%; *n*=55), characterized by low scores on self-reported overeating and LOC severity, moderate scores on food palatability, and high scores on hunger and cravings; and 3) binge-like eating (9%; *n*=60), characterized by the highest scores on all 5 indicators (see Table 2). Compared to event-contingent recordings, binge-like eating was more likely to be reported at signal-continent recordings compared to EAH (*B*=1.75, *SE*=0.61, *p*=.004) and appetitive eating (*B*=1.52, *SE*=0.70, *p*=.03). Compared to event-contingent recordings, binge-like eating was more likely to be reported at interval-contingent recordings compared to EAH (*B*=1.79, *SE*=0.65, *p*=.006). There were no significant differences between EAH and appetitive episodes with respect to signal type. There were no differences among the three classes with respect to eating episode type (meal, snack, binge, or other).

As illustrated in Table 3, binge-like eating was associated with higher positive affect compared to EAH (χ^2=4.22, *p*=.04) and with higher interpersonal problems compared to appetitive eating (χ^2=3.93, *p*=.047). EAH was associated with lower body dissatisfaction

compared to appetitive eating (χ^2=7.21, p=.007) and binge-like eating (χ^2=4.74, p=.03). Appetitive eating episodes were less likely to occur at home compared to EAH (χ^2=6.99, p=.008) and binge-like episodes (χ^2=9.08, p=.003). Binge-like eating occurred later in the day compared to EAH (χ^2=4.15, p=.04). There were no differences for negative affect or being alone.

4. Discussion

This study identified classes of eating episodes occuring in the natural environment, and their contextual correlates, among majority Black youth with overweight/obesity. We identified three episode subtypes, one resembling EAH, one resembling binge-like eating, and one characterized by appetitive states. Consistent with the previous literature, binge-like episodes tended to co-occur with psychosocial factors [i.e., interpersonal problems, body dissatisfaction; 27, 28] and in the evening [21], possibly reflecting that these types of episodes facilitate a transition from school to home (e.g., “winding down” from school), differing access to food at home versus school, or greater distress in the context of the family versus school peers. Interestingly, binge-like episodes also were associated with higher positive affect (but not negative affect), consistent with earlier work using this dataset [45]. This suggests that dysregulated eating may function to sustain positive mood [46], rather than decrease negative mood, or that binge-like eating often occurs during celebrations or other social events where excessive eating is commonplace [21]. Appetitive eating was more likely to co-occur with psychosocial factors than EAH, and also tended to occur away from home. Overall, findings suggest that weight control interventions for youth should consider contextual factors specific to different types of eating episodes, although future research is needed to clarify if these different episodes have varying qualitative (e.g., macronutrient content) or quantitative (e.g., energy composition) features.

EAH was the most common type of episode, which may reflect the sample since EAH has been associated with excess weight in youth [8]. These episodes were less likely to co-occur with psychosocial factors (i.e., body dissatisfaction, interpersonal problems) and tended to occur earlier in the day and at home. EAH episodes were also more likely than binge-like episodes to be reported at event-contingent surveys, suggesting that retrospective recall biases did not play a prominent role in reporting these episodes (although hunger ratings were derived from time-lagged recordings at the previous EMA signals). Taken together, EAH may reflect “normative” eating in racially diverse youth with overweight/obesity, meaning that youth with these characteristics experience infrequent eating episodes solely driven by homeostatic energy needs. Perceptions of hunger and its correspondence with objective markers of eating (e.g., meal size) have received surprisingly little empirical attention with respect to weight status [47], particularly in youth, and recent data suggest that the association between objective physiological indicators of appetite (i.e., pre-prandial glucose) and self-reported hunger may be distorted in individuals with overweight/obesity [48, 49]. Thus, it is unclear whether “hunger” in this sample reflects a physiological state of energy depletion or some combination of subjective appetitive factors. Further characterization of hunger and “normative” eating in youth with overweight/obesity is therefore warranted.

Past EMA research in youth has not supported negative affect as a momentary correlate or precipitant of dysregulated eating [27, 28], which contrasts findings in adults [26]. Yet, in the current study, binge-like episodes tended to co-occur with shape-/weight-related and interpersonal distress. It is possible that youth with binge-like eating are less attuned to their affective state than to cues that trigger these states (e.g., alexithymia [50]). Indeed, our group found that youth tend to report “numbing out” during LOC episodes [21]. This may be especially relevant in the late afternoon/evening, when youth are unwinding from the school day and may be processing or ruminating on aversive events from earlier in the day. Assisting these youth in recognizing affective consequences of intra- and interpersonal events may be crucial in helping them develop more adaptive coping strategies.

Although EAH and hedonic eating are associated with excess weight status [11, 51], and may co-occur with LOC and emotional eating [14, 15], they are not typically considered pathological eating behaviors in their own right. This was mostly borne out in the current study, as both types of episodes were similarly associated with most psychosocial contextual factors. One exception was that appetitive eating was associated with greater body dissatisfaction than EAH (albeit lower than binge-like eating). Eating episodes involving high levels of craving and hunger, accompanied by consumption of palatable foods, may trigger activation of the brain’s reward system [51], and hence function to distract attention from uncomfortable body-related cognitions and attitudes. Alternatively, in the presence of low levels of hunger, gastric distress (e.g., bloating) may trigger shape-/weight-related concerns or make EAH a less effective coping strategy for shape-/weight-related distress.

This study had several strengths, including the diverse, community-based sample of majority Black and Hispanic youth, and the use of ecologically valid assessment methods that reduced retrospective recall biases. Furthermore, the use of LPA to characterize eating episodes according to sensational, appetitive, and psychological characteristics was novel. Limitations included the modest between-subjects sample size, which was somewhat offset by a large within-subjects sample size (i.e., 689 distinct eating episodes). However, the average number of eating episodes reported by participants (~1.9/day) may reflect under-reporting, potentially due to children forgetting to initiate recordings, being in an inopportune place/time to complete surveys (including school, where participants were not receiving semi-random prompts and/or may not have had possession of their phones), or feeling embarrassed about eating behavior. Taken together, results should be replicated in a larger independent sample of youth with additional strategies devoted to improving compliance, such as offering higher incentives for self-initiating eating episode ratings. Further, the sample was restricted to youth aged 8–14, precluding generalizability to younger children and older adolescents. In addition, participants did not receive EMA signals during the school day, limiting the range of contextual factors that could be investigated. Other limitations included the absence of non-overweight controls; reliance on self-report/subjective assessment of indicator and validator constructs; and the cross-sectional, observational nature of data collection, which limits ability to infer causation/directionality. Finally, we did not examine the dietary composition of eating episodes making it unclear if certain classes of episodes were more likely to contribute to the maintenance of excess weight status than others.

Despite these limitations, findings are highly novel and suggest that youth with overweight/obesity may engage in eating episodes characterized by varying levels of sensational, psychological, and appetitive characteristics. An improved understanding of the contexts in which these episodes occur can inform development of targeted and optimally timed interventions for obesogenic eating behavior. Future research is needed to understand if different eating episodes classes are associated with varying levels of risk for obesity onset/weight gain (including degree of excess weight), and whether they require different approaches to treatment.

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Abbreviations:

LPA	latent profile analysis
LOC	loss of control
EAH	eating in the absence of hunger
BED	binge eating disorder
EMA	ecological momentary assessment
PANAS	Positive and Negative Affect Scale
EDE	Eating Disorder Examination
SAS-SR	Social Adjustment Scale-Self-Report
LL	log likelihood
AIC	Akaike information criterion
BIC	Bayesian information criterion
aBIC	adjusted Bayesian information criterion

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Highlights

- We used latent profile analysis (LPA) to identify classes of eating episodes
- Classes were “binge” eating, eating-in-the-absence-of-hunger, and appetitive eating
- Classes differed on environmental and psychological correlates

Table 1.

Model fit statistics for latent profile analysis

Number of Classes	BIC	aBIC	AIC	LL	Entropy
1	9602.58	9570.83	9557.23	−4768.61	-
2	8275.49	8224.69	8202.92	−4085.46	.98
3	7529.46	7459.61	7429.69	−3692.84	.99
4	6326.59	6237.68	6199.60	−3071.80	.99

Note. BIC=Bayesian information criteria; aBIC=adjusted Bayesian information criteria; AIC=Akaike information criteria; LL=log likelihood

Table 2.

Descriptive characteristics of eating-related indicators (*M* unless otherwise indicated)

	EAH (*n*=574)	**Appetitive eating (*n*=55)**	**Binge-like eating (*n*=60)**
Proportion (%) of sample endorsing at least one eating episode	39/39 (100)	21/39 (53.8)	14/39 (35.9)
Self-reported overeating	1.14[a]	1.19[a]	1.91[b]
LOC eating	1.07[a]	1.12[a]	1.73[b]
Taste	6.88[a]	6.88[a]	7.93[b]
Pre-episode (lagged) craving	1.00[a]	2.56[b]	4.71[c]
Pre-episode (lagged) hunger	1.54[a]	2.98[b]	4.36[c]

Note. EAH=eating in the absence of hunger; LOC=loss of control. Differing superscript letters indicate significant differences (p<.05).

Table 3.

Mean comparisons between latent classes on contextual validators

	EAH (*n*=574)	Appetitive eating (*n*=55)	Binge-like eating (*n*=60)
Negative affect	12.28[a]	12.84[a]	12.62[a]
Positive affect	23.36[a]	27.17[ab]	32.91[b]
Body dissatisfaction	11.05[a]	16.09[b]	18.43[b]
Interpersonal problems	5.87[ab]	5.62[b]	10.00[a]
Time of day	1.30[a]	1.44[ab]	1.48[b]
Alone (proportion)	0.30[a]	0.35[a]	0.18[a]
Home (proportion)	0.75[a]	0.55[b]	0.75[a]

Note. EAH=eating in the absence of hunger. Means with different superscripts are significantly different at $p<.05$