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Real-time Assessment of Heart Rate Variability and Loss of Control Eating in Adolescent Girls: A pilot study

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Abstract

Objective—Studying physiologic underpinnings of loss-of-control (LOC) eating may inform its etiology and contribute to intervention efforts. We therefore examined temporal relationships between autonomic indices (heart rate (HR), heart rate variability (HRV)) and LOC-eating in the natural environment.

Method—For two days, adolescents (n=17, 14.77±1.55 years, BMI-Z 2.17±0.48) with LOC-eating reported on LOC using an electronic device while HR and HRV were assessed continuously using Holter monitoring.

Results—Higher HR and lower HRV in the 30-minutes before eating were significantly associated with LOC-eating overall (*p's* < 0.001) and at the within-subjects level (*p's* < 0.001), but not at the between-subjects level (*p's* > 0.44). Examined categorically, HR was significantly higher, and HRV significantly lower, prior to high-LOC compared to low-LOC episodes (*p's* < 0.001).

Discussion—This pilot study suggests that LOC-eating may involve physiologic underpinnings. Additional research with larger samples is needed to further investigate this phenomenon.

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Keywords

LOC-eating; adolescence; heart rate; heart rate variability

Loss-of-control (LOC) eating, defined as the subjective feeling of being unable to stop eating or control what or how much one is eating, is commonly reported by community youth, with estimates ranging from 6 – 40% (1), and the highest rates observed among overweight adolescent girls (2). Predictive of excess weight gain, partial or full-syndrome binge eating disorder (BED), and depressive and anxiety symptoms (3–6), LOC-eating warrants investigation and requires intervention efforts. In particular, identifying triggers of LOC-eating in the natural environment has potential for improving LOC interventions.

Key existing LOC etiologic models hypothesize that stress and negative emotions play a role in LOC-eating (7–9). Although emotions are thought to reflect an interplay between cognitive processes (e.g. self-reported "feelings"), physiologic changes, and behavior (10), most existing investigations of predictors of LOC-eating have focused on self-report constructs (11–13). Because investigating self-reported affective states is limited by participants' ability to know and report emotions, studying physiologic indices is warranted.

Prior investigations of physiologic indices and disordered eating have examined associations at the trait-level and in response to food cues. Women with binge eating (14) and bulimia nervosa (15) experience greater heart rate increases in response to food cues. Among obese women with BED, greater cardiovascular reactivity to a psychological stressor was associated with post-stress hunger ratings (16), suggesting that physiologic stress may play a role in subsequent eating behavior.

To date, no study has examined momentary associations between cardiovascular indices (heart rate (HR) and heart rate variability (HRV)), thought to be indicative of stress (17–19), and LOC-eating. Therefore, we aimed to collect pilot data examining associations between pre-meal HR and HRV and subsequent LOC-eating. We hypothesized that HR would be positively associated, and HRV inversely associated, with LOC.

METHOD

Participants

Seventeen adolescents participating in a pilot study of the utility of ecological momentary assessment (EMA) for examining interpersonal, affective, and physiologic predictors of LOC-eating were studied. Outcome data pertaining to self-report predictors of LOC-eating are published (13). Participants were English-speaking, adolescent (12-17 y) females with a body mass index (BMI; kg/m2) at or above the 85^{th} percentile (20) who reported at least two LOC episodes during the month prior to assessment, determined using the Eating Disorder Examination (EDE) version 14.0-Interview (21). Exclusion criteria were major medical (e.g. diabetes) or psychiatric illness (e.g. major depressive disorder), use of medications affecting eating/body weight (e.g. antipsychotic class), and pregnancy. The study was approved by the Uniformed Services University of the Health Sciences (USUHS) institutional review board. Parents/guardians and adolescents provided written consent and assent, respectively.

Procedure

Participants attended a baseline screening visit during which height, fasting weight and body composition, and eating-related and general psychopathology were assessed. Adolescents practiced completing EMA recordings for one day to ensure familiarity with procedures and subsequently engaged in EMA for two weeks. Except during school, girls completed signal-contingent recordings distributed around target times of 11:10, 13:50, 16:30, 19:10, and 23:50 and event-contingent recordings before and after eating. Four items pertaining to LOC (e.g. “Did you feel a sense of loss of control?”), adapted from the EDE (21), were rated on a 5-point Likert-type scale after eating. Posture (“reclining;” “sitting;” “standing still;” “walking”) was queried at each recording.

For two days, adolescents wore a 12-lead, 9-channel Mortara H12 Holter monitor to measure HR and HRV. Data were sampled at a frequency of 1000 Hz (22). Generated ECG recordings were manually screened for clinically-relevant abnormalities and analyzed using a MATLAB-based program (23). High-frequency HRV was derived as power amplitude in the spectrum between 0.15-0.40 Hz generated by a fast-Fourier transformation. RMSSD (root mean square of successive differences), pNN50 (proportion of beat-to-beat intervals differing by >50 milliseconds), and HF HRV (high-frequency HRV) constituted indices of parasympathetically-mediated HRV as recommended (10, 22).

Data Analyses

Consistent with prior studies of HRV and eating (24, 25), physiologic indices were evaluated in the 30-minute period preceding the eating episode start time (before-meal recording). Loss-of-control was assessed after the eating episode. For after-meal LOC ratings with absent (5/40) or implausible (≤ 2 minutes before the after-meal recording, 8/40) before-meal recordings, the eating episode start time was considered to occur 28:37 minutes before the after-meal recording, based upon mean replacement with the average latency between corresponding before and after-meal recordings. Findings did not differ when analyses were restricted to episodes with a valid before-meal recording. To reduce confounding, episodes occurring within three hours of the previous episode were excluded. To evaluate LOC, a composite score comprising the average rating on three LOC items was calculated. One item (“Did it feel like you were able to stop eating?”) was excluded to improve internal reliability (13).

Three sets of analyses were performed. First, separate linear mixed models (LMM) predicting LOC from HR and HRV were conducted. Second, to parse between- versus within- subjects variability, LMM including participants’ mean (mean-centered) for each independent variable, as well as the difference between the participant’s mean and each observation, were conducted. Third, exploratory LMM were used to categorically examine the association between episode type (high-LOC versus low-LOC based on median split) and physiologic variables. All models included a random (subject-specific) intercept and a variance components correlation structure. Covariates tested included age and adiposity at the between-subjects level and before-meal posture and time of day (00:00-5:59; 6:00-11:59; 12:00-17:59; 18:00-23:59) at the within-subjects level. Posture was considered missing for eating episodes with absent/implausible before-meal recordings; when analyses were restricted to episodes with available before-meal recordings, findings were unchanged.

RESULTS

Sample and response rate

Adolescents' baseline characteristics are reported in supplementary table 1. Out of 49 eating episodes, 40 were included in analyses. Six were excluded because the episode occurred within three hours of a previous episode; three were excluded due to noisy/missing physiologic data. Slightly less than half (40-42%) of physiologic data were collected on weekends. Eighty percent of episodes occurred between 12:00 – 23:59.

Heart rate

Controlling for posture, greater HR predicted increased LOC (estimate = 0.019, SE = 0.004, $p < 0.001$, $\Delta R2 = 0.12$, Table 1a). The within (estimate = 0.019, SE = 0.004, $p < 0.001$), but not between ($p = 0.44$), -subjects level effect was also significant. Examined categorically, HR was higher prior to high-LOC (96.40±2.84 beats per minute (bpm)) compared to low-LOC (87.20±2.63 bpm, $p < 0.001$, Figure 1a) episodes.

Heart rate variability

Findings were similar for RMSSD, pNN50 and HF HRV and therefore RMSSD is presented. Controlling for posture, lower HRV was associated with higher LOC (estimate = -0.009, SE = 0.002, $p < 0.001$, $\Delta R2 = 0.14$, Table 1b). The within-subjects level effect for RMSSD was significant (estimate = -0.010, SE = 0.002, $p < 0.001$), and the between-subjects level effect was not ($p = 0.36$). Examined categorically, RMSSD was significantly lower prior to high- (41.04±9.40) compared to low- (61.66±9.21, $p < 0.001$) LOC episodes (Figure 1b).

DISCUSSION

In an initial investigation of physiological underpinnings of LOC-eating, we analyzed the associations between HR and HRV and LOC-eating in the natural environment in adolescent girls with recurrent LOC. Preliminary findings revealed significant associations between physiologic parameters and LOC overall and at the within-subjects level.

Stress and LOC-eating

Within-subjects level associations suggest that an individual is more susceptible to LOC-eating when HR is higher, and HRV is lower, than average. Since elevated HR and lower HRV can indicate stress (17), these findings suggest that LOC may be more likely to occur following stress. This finding dovetails with a naturalistic self-report study of adults in which a positive relationship between daily stress and snack intake among high-stress responders was found (26). Notably, conclusions that can be drawn from the current study are limited by the small sample size and insufficient examination of potential confounding or moderating variables, including factors varying at the person-level (e.g. pubertal status, LOC frequency/severity) and the state-level (e.g. environmental factors, physical activity, phase of menstrual cycle). In spite of this, findings set the stage for a larger investigation with more rigorous control of confounders, and provide promising data to support investigation of the mediation hypothesis that stressors predict physiologic indices, which in turn predict LOC-eating.

Potential mechanisms

From a psychological perspective, LOC-eating may be used to cope with or alleviate negative emotions, consistent with affect theories (7, 8). From a physiologic perspective, stress-induced glucoregulatory processes may contribute to LOC-eating via the production of insulin during the recovery phase of the stress response (27), which may in turn promote hunger (27, 28). Differentiating whether glucoregulatory processes specifically promote LOC, as compared to non-LOC, episodes may further elucidate this potential mechanism. It is possible that physiologic (homeostatic) and non-homeostatic factors interact to promote LOC-eating in stressful situations.

Conclusion

In conclusion, among adolescent girls, markers of physiological stress may predict LOC-eating. These findings are consistent with models of LOC as a coping strategy (7, 8). If replicated, findings point to the potential utility of physiologic indices for assessing momentary susceptibility to LOC and/or as a biofeedback tool. Especially among youth or others with difficulty self-reporting psychological constructs, physiologic indices may serve as a salient cue for LOC-eating. Future research accounting for additional influences on HR and HRV may more definitively elucidate the relation between physiologic stress and LOC-eating.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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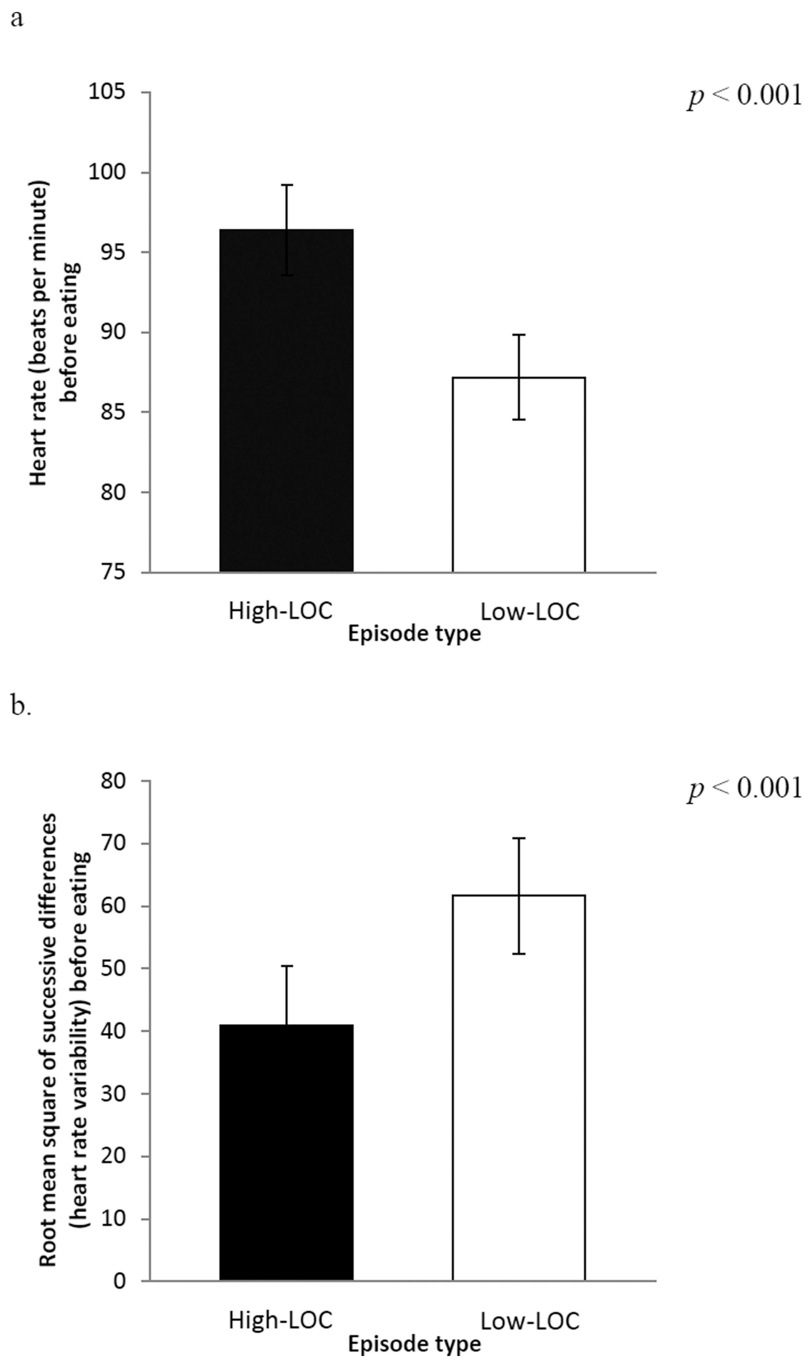

Figure 1.

Mean measured (a) heart rate and (b) root mean square of successive differences (heart rate variability) prior to eating for high- and low- loss-of-control (LOC) episodes

Table 1

Results from linear mixed models predicting level of LOC-eating from (a) heart rate (b) root mean square of successive differences (RMSSD), controlling for posture category

(a)

	Estimate	Standard Error	t Statistic	significance
Intercept	−0.487	0.424	−1.149	0.253
Heart rate	0.019	0.004	4.608	<0.001
Posture				
missing*	1.037	0.216	4.807	<0.001
walking	0.140	0.225	0.620	0.536
standing still	0.913	0.247	3.699	<0.001
sitting	0.437	0.181	2.409	0.017
reclining	reference	-	-	-

(b)

	Estimate	Standard Error	t Statistic	significance
Intercept	1.679	0.251	6.693	<0.001
RMSSD	−0.009	0.002	−4.860	<0.001
Posture				
missing*	1.137	0.214	5.315	<0.001
walking	0.112	0.224	0.499	0.618
standing still	0.852	0.246	3.471	0.001
sitting	0.434	0.180	2.412	0.017
reclining	reference	-	-	-

*Posture rating was coded "missing" for eating episodes that did not have a valid "before meal" recording and results did not differ when these episodes (k = 13) were excluded