Satiety and Test Meal Intake Among Women with Binge Eating Disorder

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ABSTRACT

Objective: The purpose of the study was to measure test meal consumption and the changes in hunger and fullness during a test meal in obese individuals with and without binge eating disorder (BED) and normal-weight controls.

Method: Twelve women with BED, 12 obese control participants, and 12 normal-weight control participants participated in two single-item test meal sessions. In one session participants were instructed to “binge,” and the other eat a normal meal. Participants made ratings of hunger and fullness on visual analog scales after every 75-g increment of food.

Results: In comparison to obese or normal-weight controls, patients with BED consumed significantly more food to reach a similar level of fullness or hunger. Individuals with BED consumed significantly more food and showed blunted changes in hunger and fullness during both the binge and non-binge meals. These findings suggest that individuals with BED may have disturbances in satiety that in some ways resemble those described among individuals with bulimia nervosa. © 2007 by Wiley Periodicals, Inc.

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Introduction

Episodes of binge eating, or eating a large amount of food accompanied by a sense of loss of control, are the behavioral hallmark of both binge eating disorder (BED) and bulimia nervosa (BN). A number of laboratory studies have been conducted to measure food consumption objectively during episodes of binge eating under controlled circumstances. When asked to binge eat in the laboratory, patients with BN consume considerably more food and eat faster than control participants. Similarly, studies have consistently demonstrated that during a binge meal, obese individuals with BED consume more than control participants without BED. Binge size correlates significantly and positively with Body Mass Index (BMI) among patients with BED; however, the average binge meal size of patients with BED is less than patients with BN under similar laboratory circumstances.

In addition to measuring food consumption, some studies of eating behavior have assessed participants’ subjective experience during the meal, including changes in hunger and fullness. Patients with BN appear to demonstrate a disturbance in the development of fullness during the course of a test meal. Although patients with BN reach a similar level of fullness as control participants during a binge meal, they require much greater quantities of food to reach this level, but when asked to eat normally, a preliminary report suggested that patients with BN report feeling less full than controls. Although patients with BED and individuals with BN share a common behavioral disturbance, binge eating, less is known about the subjective experience of patients with BED, including whether patients with BED report similar disturbances in the development of fullness during laboratory meals. The presence of purging in BN and differences in eating patterns within and outside of binge...
episodes in participants with BED versus those with BN suggest that the particular disturbances in satiety mechanisms may differ between the two groups.

Thus, the current study is similar to a previous investigation among patients with BN, and was designed to determine whether the disturbance in perceptions of hunger or fullness would also be found among patients with BED. The study measured self-reported ratings of hunger and fullness among patients with BED during two laboratory test meals, in which participants were instructed to either “binge,” or eat without binge eating or restricting. We hypothesized that patients with BED would demonstrate a disturbance in fullness when compared with women without BED. A similar, but potentially more severe disturbance has been previously observed among patients with BN (see Ref. 3). In addition, the utility of the diagnosis of BED continues to be questioned, because of data demonstrating high placebo response rates, substantial reductions in binge eating with nonspecific treatment (e.g., behavioral weight loss programs), and reactivity of symptoms. Some have argued that the current diagnostic criteria for BED may result in difficulties in distinguishing patients with true BED and individuals without an eating disorder (e.g., obese individuals). Therefore, the current study also provided the opportunity to evaluate whether patients with BED could be distinguished from obese individuals without an eating disorder on the basis of eating behavior and the changes in hunger and fullness in the binge and nonbinge meals.

Method

Participants

Twelve women meeting the proposed DSM-IV criteria for BED, as defined in the Appendix of the Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition (DSM-IV), participated in this experiment. Individuals with BED were between the ages of 18 and 45 years, with a BMI (kg/m²) greater than 38, who responded to advertisements offering outpatient treatment in exchange for research participation. Patients were free from serious psychiatric disorders (e.g., bipolar disorder), significant medical illnesses or suicidality, and could not be taking psychotropic medications.

Twenty-four women without eating disorder symptoms served as the control group. Twelve controls were obese, and 12 were at a normal weight. Obese controls had a BMI greater than 38 kg/m² and normal-weight controls were between 90 and 120% of ideal body weight for height (BMI range of 19.74–26.5). All control participants participated in the study in exchange for monetary compensation, and were required to be free from medications (except birth control) and without a current or past psychiatric diagnosis or significant medical illness.

The eligibility of BED patients, obese controls, and normal-weight controls was assessed during an in-person evaluation, where informed consent was also obtained. This study was reviewed and approved by the Institutional Review Boards of the New York State Psychiatric Institute and St. Luke’s-Roosevelt Hospital.

Procedures

The procedures of this study have been described in detail elsewhere; however, in this study, the test meal was macaroni and cheese, rather than a yogurt shake. All participants completed three test sessions on nonconsecutive days: a screening/adaptation meal, a binge meal, and a nonbinge meal. Presentation of the binge and nonbinge meals was counterbalanced so that potential order effects would be minimized in the overall analysis. Participants reported to the laboratory after an overnight fast. On the morning of each test session, patients and controls consumed a standardized breakfast consisting of one Thomas’ English Muffin with 1.5 pats of butter and 249 g of Red Cheek natural apple juice (~300 kcal). Participants were asked not to consume any additional food or liquid, other than water, before reporting back to the lab 6 h later. Compliance with the overnight and 6-h fast was assessed by questionnaire on both the binge and nonbinge days when participants reported for the breakfast session and at the afternoon test meal. Any individuals who did not comply with the procedures for fasting did not complete research meals on that day.

The test meals consisted of six 12-oz packages of Stouffer’s macaroni and cheese (two servings per package; 250 kcal, 12 g protein, 22 g carbohydrate, 13 g fat per serving) for a total of 12 servings; 3,000 kcal, and 4.5 pounds of food presented in a 2-quart round white Corningware bowl (upper diameter = 26 cm, lower diameter = 13 cm, height = 7 cm). The amount of food available for consumption was therefore consistent with the definition of an objective bulimic episode as defined by the Eating Disorder Examination, which designates the consumption of three main courses (e.g., 3 Big Macs) as objectively large. Before each test meal, participants received instructions via tape recorder, and during the meal, they were observed through a closed circuit video monitor. Instructions prior to the binge meal were to “Let yourself go and binge eat. If you are someone who binge eats regularly, we would like your behavior here to resemble your behavior at home as much as possible. If you are someone who does not binge eat, we would like you to let yourself go and overeat.” Prior to the nonbinge
meal, participants were instructed to “eat as much as you would eat in a normal meal in a relaxed atmosphere.” The food was placed upon an eating monitor, which continuously recorded the weight remaining throughout the meal. Prior to the start of the meal, participants were asked to make subjective ratings of hunger and fullness, desire for eating a favorite food, and sickness on 15 cm Visual Analog Scales (VAS) anchored by the phrases “Not at all” and “Extremely.” At 75-g intervals during the binge and nonbinge meals participants were signaled by a tone from a remotely controlled tape recorder to complete VAS assessing hunger and fullness. After the meal, participants completed VAS ratings of hunger, fullness, pleasantness, desire for eating a favorite food, sickness, and feelings of having eaten enough.

Measures
Participants completed the Beck Depression Inventory (BDI) and the Three Factor Eating Questionnaire (TFEQ) during the in-person eligibility evaluation prior to the initiation of study procedures. Frequency of binge eating and duration of illness for the BED patients were assessed by clinical interview. Measures of height and weight were taken for all participants.

Data Analysis
Only data from the binge and nonbinge meals were analyzed, as the first test meal was designed to be a screening/adaptation meal. The main outcome variables were the participants’ VAS ratings and test meal intake. The minimum and maximum VAS ratings of hunger and fullness during the binge and nonbinge meals were calculated. If the minimum or maximum VAS rating occurred more than once during the meal, only the first minimum or maximum VAS rating was analyzed. The minimum and maximum ratings of fullness and hunger corresponded to the amount of food a patient had consumed at the time when the maximum or minimum VAS rating was made.

A rating range for hunger and fullness (the maximum rating—the minimum rating) was calculated for each patient during both the binge and nonbinge meal. The value for the ratings range was then divided by four, which established hunger or fullness quartiles (e.g., 25, 50, and 75% of maximum fullness or hunger). Since the hunger and fullness quartiles were interpolated from the ratings range, they did not necessarily correspond to a rating made by the patient during a meal. Therefore, the lower and upper bound of the quartile, or the actual VAS ratings that were closest to the quartile value, were determined. The lower and upper bounds were found by identifying the fullness/hunger rating immediately preceding and following each quartile value. Once these bounds were obtained, an interpolated intake was calculated for each quartile, based on the intake at the lower and upper bounds at the quartile, the fullness/hunger rating at the quartile, and the upper and lower bounds of the fullness/hunger rating at the quartile.

Repeated measures Analyses of Variance (ANOVAs) were calculated for total intake during the meals, the hunger and fullness quartiles, and the intake at each fullness or hunger quartile. When Mauchly’s test of sphericity was significant, the degrees of freedom and p-values were Greenhouse–Geisser corrected. If the epsilon value for the Greenhouse–Geisser test was larger than 0.75, Huynh–Feldt corrected values were used. Post hoc one-way ANOVAs were conducted to examine differences between BED patients, obese controls, and normal-weight controls for each of the repeated measures ANOVAs. The alpha values for the post hoc ANOVAS were divided by three in accord with the Bonferroni correction for multiple comparisons (p ≤ .05/3, or p ≤ .017). One way ANOVAs were also used to assess differences between the BED patients, obese controls, and normal-weight controls on demographic variables, the BDI, and the subscales of the TFEQ. Pearson’s correlation coefficients were calculated between BMI and total mean intake during the binge and nonbinge meals for each of the three participant groups.

All calculations were performed using SPSS for Windows, version 11.5. Means are reported ± standard deviations (SD).

Results
Demographic Characteristics
The mean age, body mass indices (BMI; kg/m²), BDI scores, and TFEQ subscale scores for BED patients, obese controls, and normal-weight controls are presented in Table 1. The mean duration of illness for BED patients was 12.45 ± 6.77 years (range of 3–22 years), and the mean number of binge eating episodes per week was 5.58 ± 5.13 (range of 2–21 episodes). Eleven of the 36 participants (30.55%) were Caucasian (3 BED, 4 obese controls, and 4 normal-weight controls), 21 (58.33%) were African-American (7 BED, 7 obese controls, and 7 normal-weight controls), three (8.33%) were Hispanic (2 BED, 1 normal-weight control), and one (2.78%) was Indian American (obese control). There were no significant differences in the distribution of ethnicity between the groups.

Intake
In the binge meal, BED patients consumed 943.15 ± 271.44 g, obese controls consumed 552.06 ± 252.16 g, and normal-weight controls consumed
475.83 ± 161.04 g. In the nonbinge meal, BED patients consumed 622.18 ± 202.24 g, obese controls consumed 397.24 ± 162.80 g, and normal-weight controls consumed 368.02 ± 102.69 g. The repeated measures ANOVA for the total intake during the binge and nonbinge meals (within subjects factor) and diagnostic group (between subjects factor) found a significant main effect of diagnostic group \([F(2,33) = 14.55, p < .001]\), meal \([F(1,33) = 38.40, p < .001]\), and a significant meal by group interaction \([F(2,33) = 4.24, p = .02]\). Post hoc tests demonstrated that intake between the binge and nonbinge meals differed significantly between BED patients and obese controls \((p < .001)\) and normal-weight controls \((p < .001)\), but there were no differences between the obese and normal-weight control groups \((p = NS)\).

**Hunger and Fullness Quartiles**

For the within subjects factors of fullness quartile (minimum, 25, 50, 75, and maximum) and meal (binge and nonbinge) and the between subjects factor of diagnostic group there was a significant main effect of diagnostic group \([F(1,132) = 25.38, p < .001]\), and quartile \([F(4,132) = 8.18, p < .001]\) and significant interactions between quartile and diagnostic group \([F(8,132) = 3.92, p < .001]\) and quartile and meal \([F(4,132) = 18.49, p < .001]\). The main effect of diagnostic group \([F(2,33) = 0.127, p = NS]\) and the interactions of meal and diagnostic group \([F(2,132) = 0.745, p = NS]\) and quartile, meal, and diagnostic group \([F(8,132) = 0.471, p = NS]\) were not significant. Post hoc one-way ANOVAs with an adjusted alpha level \((p \leq .017)\) found no significant differences between the three diagnostic groups for any of the fullness quartiles (minimum, 25, 50, 75, and maximum) during the binge or nonbinge meals.

The repeated measures ANOVA of the within subjects factors of hunger quartile (minimum, 25, 50, 75, and maximum) and meal (binge and nonbinge) and the between subjects factor of diagnostic group found a significant main effect of quartile \([F(4,132) = 3.03, p < .001]\). The main effects of meal \([F(1,132) = 3.10, p = NS]\) and diagnostic group \([F(2,33) = 0.30, p = NS]\) and the interactions between meal and diagnostic group \([F(2,132) = 0.57, p < .001]\) and significant interactions between fullness quartile and diagnostic group \([F(4,132) = 4.61, p < .001]\) and fullness quartile and meal \([F(4,132) = 5.57, p < .001]\). The interactions of meal and diagnostic group \([F(2,132) = 1.79, p = NS]\) and fullness quartile, meal, and
diagnostic group \[ F(8,132) = 0.547, \ p = \text{NS} \] were not significant. All significant differences \( (p < .017) \) for both meals are noted in Figure 1. Patients with BED differed from the normal-weight controls at every percentile except minimum fullness, and differences also emerged between the BED patients and the obese controls toward the larger percentiles (see Fig. 1).

For intake at the hunger quartiles (intake at minimum hunger, 25, 50, 75%, and maximum hunger) there was a significant main effect of quartiles \[ F(2.20, 132) = 134.90, \ p < .001 \], meal \[ F(1,132) = 25.32, \ p < .001 \], and diagnostic group \[ F(2,33) = 10.52, \ p < .001 \] and significant interactions between quartile and diagnostic group \[ F(8,132) = 5.19, \ p < .001 \] and between quartile and meal \[ F(2.78, 132) = 8.57, \ p < .001 \]. The interactions of meal and diagnostic group \[ F(2,132) = 1.69, \ p = \text{NS} \] and quartile, meal, and diagnostic group \[ F(8,132) = 1.15, \ p = \text{NS} \] were not significant. Similar to the pattern observed with intake at the fullness quartiles, most of the significant differences were observed between BED patients and normal-weight controls, but differences were also observed with obese controls at the higher quartiles in the binge meal (see Fig. 2).
Correlation of Intake and BMI

None of the correlations between BMI and meal size on the binge or nonbinge days for any of the three groups were significant.

Conclusion

Similar to previous eating behavior studies (for a review, see Ref. 6), this study found that individuals with BED consumed significantly more food than both obese and normal-weight controls after being instructed to either binge eat or eat a normal meal. When asked to complete VAS ratings of hunger and fullness during the test meals, BED patients reported a similar absolute level of fullness and hunger to that of obese and normal-weight controls during the test meals. However, among the BED patients, particularly during the binge meals, the meals were consistently of a larger size. Although patients with BED did not experience greater absolute levels of hunger or fullness on the VAS, they objectively consumed more of the test meal. Thus, the diagnosis of BED may help to differentiate the eating behavior of overweight individuals with and without recurrent binge eating episodes.
To further probe the differences between patients with BED, obese controls, and normal-weight controls, we examined the amount of food consumed when each participant was at their minimum, 25, 50, 75%, and maximum fullness or hunger on the VAS. Post hoc tests found that during the binge and nonbinge meals, BED patients diverge from normal-weight controls in fullness ratings at 25% of maximum fullness, and continued to differ until reaching maximum fullness. In comparison to obese controls, BED patients diverge at the fullness ratings at 75% of maximum fullness to maximum fullness during the binge meal and at maximum fullness during the nonbinge meal. For the VAS hunger ratings, the post hoc tests showed a similar pattern. In the binge and nonbinge meals, BED patients and normal-weight controls differed in hunger ratings at the minimum hunger rating through the rating of 50% of maximum hunger. BED patients diverged from obese controls less often, with differences at the minimum hunger rating and 25% of maximum hunger rating for the binge meal, but the ratings of the two groups did not differ during the nonbinge meal.

Thus, the consumption of BED patients during both binge and nonbinge meals appears to be characterized by a diminished increase in fullness and decrease in hunger per unit consumed, particularly during the latter portion of the meal. The diminished increase in fullness during a binge meal observed in the current study is similar to the disturbance in the development of fullness among patients with BN observed in previous studies. However, it is not possible to directly compare the development of fullness between patients with BN and BED, as the current study and the study by Kissileff et al. used different experimental meals (macaroni and cheese vs. yogurt shake). As patients with BED show a disturbance in self-reported hunger and fullness, in comparison to both control groups, when asked to eat normally or binge eat, especially towards the end of the meals, these individuals could be less responsive than either normal-weight or obese controls to the signals that lead to meal termination. The blunted feelings of hunger and fullness observed in this study indicate that these patients may continue to experience episodes of overeating and binge eating because they do not experience cues used by obese and normal-weight controls to discontinue eating. However, as the difference in self-reported hunger and fullness were less striking between patients with BED and obese controls, additional studies of the perception of satiety between these groups are needed.

There are limitations to the design of this study. The sample size was small, which may limit the generalizability of the findings, a single-item meal of macaroni-and-cheese was used, which could have affected intake and subjective responses as the choice of food consumed was not left to the participant, and only a selected number of constructs related to the perception of satiety were assessed. Although compliance with instructions to fast, either overnight or in the 6 h between breakfast and the test meals, was assessed by self-report on both test days, and noncompliant participants were excluded from participation in the meals, participants were not held in a controlled research environment. Thus, participants may have consumed calories outside of the research meals on the test days, which may have affected total intake in the binge or nonbinge meals. In addition, the subjective ratings of hunger and fullness in this study may have been influenced by the experimental design, including participants’ knowledge of the design prior to the test meals (e.g., that they would be asked to binge eat and eat normally as part of the experiment), the instructions given prior to the binge and nonbinge meals, or expectations associated with the experience of binge eating or eating normally. Bartoshuk et al. have suggested methods to address the potential influence of the experimental design on subjective ratings in laboratory meals; however, those methods were not used in the current study. Finally, as in all studies of eating behavior in a laboratory setting, it is not clear how closely binge and nonbinge meals in this experiment resemble those of a more naturalistic eating environment. It is possible that the laboratory setting induces different behavioral responses in patients with BED and obese controls. Patients with BED consistently eat significantly more than obese controls in laboratory settings, but both groups are usually of similar weight. The experience of eating in the laboratory may therefore disinhibit patients with BED and inhibit obese controls, which results in differences observed between the groups in total intake. However, the use of a laboratory paradigm does allow for the objective measurement of intake and the assessment of subjective responses under identical experimental conditions, thereby eliminating a number of potential sources of variability.

The limitations of the current study and other laboratory feeding studies suggest that future research should examine more objective measures of disturbances in the development of fullness, including physiological mechanisms maintaining...
these disturbances. Some physical processes underlying the perception and hunger and fullness appear to be disturbed among patients with BN, including gastric emptying,\textsuperscript{17–22} release of the hormone cholecystokinin (CCK\textsuperscript{18,23,24}), gastric capacity,\textsuperscript{19} and gastric relaxation.\textsuperscript{25} One preliminary study investigating similar processes among patients with BED found that gastric capacity in patients with BED was larger than that of nonbinge eating overweight participants, but there was no evidence that gastric emptying was slowed or that release of the hormone CCK was altered among patients with BED.\textsuperscript{26} Although this study provides some evidence for a disturbance in one physiological processes contributing to the development of satiety among patients with BED,\textsuperscript{26} additional studies are needed to better understand the role of these physical processes in the maintenance of binge eating.

In summary, this study demonstrated that patients with BED consume significantly more than both obese and normal-weight controls during test meals when they were asked both to binge eat and eat a normal meal. Patients with BED also generally consumed significantly more food to eat and eat a normal meal. Patients with BED also generally consumed significantly more food to reach a similar level of fullness or to reduce hunger to a similar level at meal termination compared with obese or normal-weight control participants. These observations suggest there may be a disturbance in the perception of satiety similar to that previously described among patients with BN. Additional studies are needed to determine the clinical significance of this finding and to establish whether differences in self-reported ratings of hunger and fullness resolve after successful treatment for BED.

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