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Comparisons of Energy Intake and Energy Expenditure in Obese Women with and Without Binge Eating Disorder

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Abstract

The purpose of this study was to determine whether there are differences in energy intake or energy expenditure that distinguish overweight/obese women with and without binge eating disorder (BED). Seventeen overweight/obese women with BED and 17 overweight/obese controls completed random 24-hour dietary recall interviews, and had total daily energy expenditure (TDEE) assessed by the doubly labeled water (DLW) technique with concurrent food log data collection. Participants received two baseline dual energy x-ray absorptiometry (DXA) scans and had basal metabolic rate (BMR) and thermic effect of food (TEF) measured using indirect calorimetry. Results indicated no between group differences in TDEE, BMR and TEF. As in our previous work, according to dietary recall data, the BED group had significantly higher caloric intake on days when they had binge eating episodes than on days when they did not (3255 vs. 2343 kilocalories (kcal)). There was no difference between BED non-binge day intake and control group intake (2233 vs. 2140 kcal). Similar results were found for food log data. Dietary recall data indicated a trend toward higher average daily intake in the BED group (2587 vs. 2140 kcal). Furthermore, when comparing TDEE to dietary recall and food log data, both groups displayed significant underreporting of caloric intake of similar magnitudes ranging 20–33%. Predicted energy requirements estimated via the Harris-Benedict equation underestimated measured TDEE by 23–24%. Our data suggest that increased energy intake reported by BED individuals is due to increased food consumption and not metabolic or underreporting differences.

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Disclosure

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INTRODUCTION

With the pending publication of the Diagnostic and Statistical Manual for Mental Disorders Fifth Edition, there is still debate on how the eating disorders section should be organized and what disorders should be included. One of the critical questions regarding whether binge eating disorder (BED), which now appears in Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV) under an appendix entitled, "Criteria Sets…for Further Study", should be included as a diagnosis relates to whether BED can be distinguished from typical obesity. Currently approximately a third of the American population is obese with another third overweight(1). Eating disorders researchers posit that the prevalence of BED is much lower, ~5% of the obese population (2) and between 18 and 46% of those seeking treatment in weight loss programs (3). Additionally, the prevalence of BED in patients presenting for bariatric surgery has been estimated between 10 and 50% (4–10). This study was designed to examine whether there are differences in energy intake or energy expenditure patterns which distinguish those with BED from typical overweight/obese controls. Differences in these biological and behavioral factors between groups may help to clarify whether BED is a distinct eating disorder from obesity by identifying metabolic and food intake differences between groups.

Work by our group and others has documented that participants with BED consume significantly more total energy than non-BED obese according to self-reported data (11) and laboratory overeating episodes (12–16). For example, Yanovski and Sebring (11) reported that those with BED consumed significantly more kcal according to self-reported food records than a weight matched non-BED group (2707 vs. 1869 kcal). Self-reported data has also demonstrated that those with BED consume significantly more food on binge days than on non-binge days (17) and than non-BED obese on average (18). In this study, we attempted to replicate the finding that BED participants eat more on days when they binge eat than on days when they do not and more than non-BED overweight/obese on average using random dietary recall interviews and self-reported food log data.

In addition to the evidence cited above that indicated women with BED have higher caloric intake, there is additional indirect evidence that women with BED are eating more than they expend. As discussed above, the proportion of women with BED in obese samples increases as BMI increases (2–4). This suggests those with BED are overeating more than non-BED obese women and gaining weight more rapidly, resulting in greater representation in the higher BMI groups.

Previous research comparing intake to energy expenditure indicated that it is typical for normal weight and obese individuals to report intake at ~60% of predicted energy expenditure when they are weight stable (19–20). Yanovski's BED group reported energy intake equivalent to 94% of their predicted energy requirements based on the Harris-Benedict Equation (HBE) (21) compared to 60% in non-BED obese group (11). The authors suggested that the BED group may be more accurate in reporting food intake than controls. Alternately, the BED participants may underreport energy intake to the same degree as the non-BED group. If this were the case, their actual intake would exceed 4500 kcal per day (based on self-reporteded food intake of 2707 kcal/day in Yanovski and Sebring). Excess food intake of this caliber would place the BED group in a chronic state of positive energy balance; taking in about 1500 kcals per day over predicted energy expenditure of 2880 Kcals/day calculated using the HBE.

According to previous reports in the literature, having a positive energy balance (chronic overfeeding) leads to increased TDEE (22–24). TDEE is most accurately measured using doubly labeled water (DLW) which is the gold standard for assessing total daily energy

expenditure (TDEE) in free-living individuals. The method relies on the differential elimination of ^{18}O and ^{2}H (deuterium) from the body. Both isotopes equilibrate in total body water space. The ^{2}H is eliminated from the body exclusively as water, primarily in the urine. The ^{18}O is eliminated from the body both as water and as labeled carbon dioxide at a rate that is dependent on the release of CO_2 as a byproduct of substrate oxidation. TDEE can be determined using formulas that predict the CO_2 production rate from the differential losses of ^{2}H and ^{18}O from body water. Components of TDEE, such as basal metabolic rate (BMR) and thermic effect of food (TEF), can be measured by in the laboratory by indirect calorimetry.

Several lines of evidence indicate that those with BED eat significantly more than BMI-matched obese individuals both in the laboratory and according to food records. The components of TDEE include BMR, TEF, physical activity, and nonexercise activity thermogenesis (25,26). Our methodology allowed us to make accurate measurements of BMR, TEF, and weight change during the two weeks of urine collection to determine TDEE by DLW analysis.

We hypothesized, based on the literature and our previous data, that the BED group would consume more kcal per day than the non-BED overweight/obese controls. Secondly, we hypothesize that those with BED are in a constant state of positive energy balance and therefore will have an elevated TDEE compared to the nonbinge eating women. Based on previous data by Yanovsky and Sebring (11), we hypothesized that those with BED would be more accurate than non-BED individuals in reporting energy intake. As Yanovski observed, increased accuracy could be due to the fact that the psychological distress associated with eating in those with BED leads to more accurate recollection of actual intake (11).

METHODS AND PROCEDURES

Participants

Participants were 17 women who met DSM IV (27) criteria for BED as defined in the appendix titled *Criteria Sets and Axes Provided for Further Study* and 17 women with no history of eating disorder symptoms including binge eating or purging behaviors. In order to participate in the study, women were required to be between the ages of 18 and 45, have no history of substance abuse or dependence within the six months prior to the study, and have no unstable comorbid medical or psychiatric conditions. Participants could not be smokers, pregnant, nursing or on a weight reduction diet as all of these conditions affect energy metabolism. Because of the difficulty recruiting participants free of psychiatric medications, participants were not excluded if they were on a stable dose (for at least 6 months) of antidepressant medication, were psychiatrically stable and had no plans to modify their medication during the duration of the study. Six participants with BED and two controls were on antidepressants during the time they were participating in the study. Participants who were on medication for thyroid disorders also had to be on a stable dose of medication for at least six months with normal thyroid function tests. One control was on thyroid replacement medications. All participants underwent a physical exam, blood pressure screening, and laboratory studies including complete blood count, thyroid function test, liver function test, and basic metabolic panel to screen for covert medical conditions. The study was conducted at the General Clinical Research Center (GCRC) of the University of Minnesota (Minneapolis, MN). This protocol was reviewed and approved by the Institutional Review Board at the University of Minnesota and all participants partook in the informed consent process and signed a consent form.

Procedures

Participants were recruited through newspaper advertisements, online advertising, and posters. The advertisements invited women between the ages of 18 and 45 who had problems with binge eating or compulsive overeating to participate in a paid research study. Advertisements for control participants asked for those interested in being involved in obesity research. Participants were screened over the telephone. Appropriate candidates were scheduled for an initial visit during which they were interviewed using the Structured Clinical Interview for DSM IV Axis 1 Disorders Patient Edition (SCID-I/P) and the Eating Disorder Examination, version 12.0D, to confirm BED status and determine eligibility.

Eligible participants were scheduled for two procedures, six random 24-hour dietary recall interviews and a 24-hour inpatient stay on the GCRC. On the day of admission, participants were instructed not to eat after 12:00 noon. While on the inpatient unit, they consumed DLW for the TDEE measurement, received two baseline (dual-energy X-ray absorptiometry (DXA)) scans and had BMR and TEF measured using indirect calorimetry. Details of each of these methods are provided below. Participants' height and weight were measured on admission. Weight was repeated 2 weeks later. The inpatient stay was scheduled to coincide with the luteal phase of the menstrual cycle, confirmed by estradiol and progesterone levels, to control for hormonal influences on food intake.

Twenty-Four Hour Dietary Recall—Over a 6–8 week period of time (that excluded the DLW data collection period) each participant received six random 24-hour dietary recall interviews that were conducted by the staff of the Nutrition Coordinating Center (NCC), Department of Epidemiology, School of Public Health, University of Minnesota. Four of the six were conducted during weekdays and two on weekends as this best approximates normal intake (28). All participants were trained in the use of food portion visuals to estimate consumption. Interviewers collected dietary recalls using a current version of the database each year. At the end of data collection nutrients were calculated for all dietary intake records on the most current version of the Nutrition Data System for Research (NDS-R) software version 4.01, Food and Nutrient Database 30, released November 1999. NDS-R is developed and maintained by the NCC, University of Minnesota, Minneapolis, MN. Details of the 24-hour dietary recall procedure have been described in previous publications by our group (14,29).

Food log—During the two weeks of urine collection participants also kept a food diary so that recorded intake could be compared to measured TDEE during the 2 week period of time. Participants were trained in the use of food logs by a training tape provided by the GCRC dietician. Food logs were routinely reviewed by the research team and further questions regarding intake were asked if recorded data lacked sufficient detail for calculation of energy intake.

BMR and TEF—BMR and TEF were measured using the Delta Track Metabolic Cart (SensorMedics, Yorba Linda, CA). BMR and TEF were collected for two participants (one BED and one control) on a SensorMedics Vmax 29 Metabolic cart (SensorMedics) because of technical issues with equipment. Participants were awakened at a standardized morning hour, allowed to void, and then rested for one-half hour before BMR was measured. BMR was assessed using a thirty minute recording under the plastic hood while awake, in a semirecumbent position in bed. The first 10 minutes were used to obtain a stable baseline. BMR was then calculated from the average of the next 20 minutes of data collection. Participants then drank a standardized oral meal replacement formula (Ensure High Protein, Abbot Laboratories, Abbot Park, IL) which contained 250 kcal (protein 14.4%, carbohydrate 64.0%, Fat 21.6%). TEF or postprandial thermogenesis was measured based on data

collected over the next 5 hours by placing the participant under the hood to collect data for 15 minutes of every 30 minutes to prevent participant fatigue or agitation. The first 5 minutes of every 15-min period was used to establish a stable baseline. Conventional methods were used to calculate daily TEF.

TDEE—TDEE was measured over 14 days using the DLW protocol (25,30,31). Baseline urine specimens were collected immediately prior to the timed ingestion of the isotopes (^{2}H and O^{18}). The amount administered was calculated according to a standardized procedure (25,26). Following timed administration of the isotopes, urine samples were collected at 12-h intervals each day for 14 days. Date and exact collection times were recorded on each bottle and specimens were dropped off to the clinic every 3–4 days during the 2 weeks of data collection. TDEE was derived using the slope-intercept equations described by Coward, et al. (32). Validation studies have determined the precision of the method to be within 4–5% (33).

Assessment of Change in body composition through repeated DXA scans—Two baseline DXA scans (Lunar Prodigy, General Electric Medical, Madison, WI) were collected on the day the DLW was administered. They were repeated two weeks later at the completion of DLW protocol. Assessment of body composition is essential because if body weight and composition are stable, energy intake must be equal to energy expenditure. Collection of body composition data allows for an accurate comparison of food intake data (collected via dietary recalls and food logs) to the TDEE measured by DLW. If there was no change in body weight or composition, the measured TDEE should be equal to energy intake. Therefore, by comparing reported food intake to measured energy expenditure, we examined the accuracy of food log data kept over the 2-week period when TDEE was assessed.

Predicted energy requirements—The HBE, commonly used in clinical settings, calculates resting metabolic rate based on gender, weight, height and age (34). Predicted energy requirements can be made by adjusting for activity level. To attain predicted energy needs, participants' HBE estimates were multiplied by 1.35 to account for light activity.

Analyses

Analysis of DLW by Isotope Ratio/Mass Spectrometry—Deuterium and ^{18}O in urine were measured using a dual inlet ThermoFinnigan DeltaS Isotope Ratio Mass Spectrometer (ThermoFisher Scientific, Bremen, Germany). Deuterium was analyzed using an H-Device by reducing 1μL water via a chromium furnace held at 825°C. The deuterium produced was measured against a calibrated hydrogen reference gas. ^{18}O was measured in a separate assay by equilibration of urine with CO_2. One milliliter urine was introduced into a 12ml exetainer and 5% CO_2 in Helium added to the tube. The sample was then allowed to equilibrate overnight at room temperature. Analysis of the $C^{18}O^{16}O$ produced was performed by measurement against a CO_2 reference gas using a breath bench carousel inlet. In both assays, calibration curves were prepared to which the samples were compared.

Statistical Analysis Methods—Analysis of Variance was used to determine between group differences on metabolic measures and average daily total caloric intake measured by 24-hour recalls and food logs. A paired Student's *t* test was used to compare within subject average caloric intake on binge days vs. non-binge days. Descriptive statistics and group differences were calculated using SPSS version 17.0. P-values of < 0.05 indicated statistical significance.

RESULTS

Demographic Data

There were no statistically significant differences between groups with regard to age and BMI (See Table 1). The BMI range for the participants was 25.6 to 51.9 with 20.7% of the sample overweight (four BEDs and two controls). Baseline binge frequency according to EDE assessments in the BED group ranged from twice per week to daily with a group mean of 17 episodes per month (median = 12).

Metabolic measurements

There were no between group differences in TDEE, BMR, or TEF (See Table 1). TDEE was significantly correlated with total food intake in kcals as assessed by 24-hour recall in the whole sample (n=29, r^2 = .422, p = .025) but not by food logs. When the two groups were examined separately there was no significant correlation between TDEE and intake as assessed by dietary recall in the BED group, but there was a trend that indicated a possible correlation in the control group (n = 13, r^2 = .522, p = .056.)

Body Composition

There were no differences between groups on baseline measures of fat and lean tissue compartment, follow-up fat and lean tissue compartments or on change in fat, change in lean, according to the DXA scan data. There were also no within group differences in baseline and follow-up on fat or lean tissue compartments. There were no within or between group differences in weight from baseline to follow-up.

Random 24-Hour Dietary Recall Data

BED participants had an average of 2.29 binge days during the 6 dietary recalls (median = 2, range = (0.5)). The BED group had a significantly higher caloric intake on days when they had binge eating episodes than on days when they did not (see Table 3). Additionally, caloric intake in the BED group on binge days was significantly higher than control average intake. There was no difference between BED non-binge day intake and control intake (see Table 2). There was a trend toward higher average daily intake in the BED group (p=0.053). There was a significant group difference in number of kilocalories consumed per unit of BMI with the BED group consuming 76.2 kcals/BMI unit and the controls consuming 61.0 kcals/BMI unit.

Food Log Data

BED participants had an average of 7.5 binge days during 14 days of food log entries (median = 7.5, range = (4.11)). The food log data corroborated that BED participants consumed significantly more kcals on binge days than non-binge days (Table 3) and had greater intake on binge days than controls (Table 2). The BED group had similar intake on non-binge days to controls. There were no significant differences in average intake or kcals/BMI unit between groups according to food log data.

Energy expenditure versus reported intake

Daily intake as reported by the 24-hour recall data and the food log data were compared to actual TDEE as assessed by DLW (Table 4). BED participants reported caloric intake that was 80% of TDEE according to dietary recall data and 70% of TDEE according to food log data. Control participants reported caloric intake that was 67% and 72% of TDEE according to dietary recall and food log data, respectively. There were no significant group differences in under-reporting between groups.

Predicted energy requirements versus energy expenditure

There were no between group differences on HBE predicted energy requirements. When comparing predicted energy requirements to actual TDEE there were no group differences. Predicted energy requirements accounted for 76% and 77% of actual TDEE for BED and control groups respectively (Table 4).

DISCUSSION

The data do not support the hypothesis of higher energy expenditure in the BED group as there were no statistical differences in TDEE, BMR, or TEF between BED participants and overweight/obese controls. Using the DLW method in the current study, TDEE was 3,214 and 3,172 kcal/day in BED and non-BED obese participants, respectively. To the best of our knowledge, this is the first study to measure TDEE by the DLW method in overweight/obese females with BED. Obesity researchers using DLW to measure TDEE have reported values ranging from 2,090 kcal/day in obese females during periods of dietary restraint (35) to 3,708 kcal/day in obese females with a mean BMI of 37.4 kg/m2 (36). Examining studies of obese females with a BMI range from 29.6 to 33.0, the reported TDEE ranged from 2,452 to 2,952 kcal/day (37–41). The high TDEE in our study may be a result of higher BMI in our BED (34.8) and control groups (35.2) that approached that of Platte's participants (37.4) (36). Measurements of BMR in our BED and control groups are consistent with those for obese females reported in the literature ranging from 1502 kcal/day to 1,680 kcal/day (37,39,40). As stated above, we found no difference between BED and non-BED obese in the TEF. Some researchers have demonstrated decreased TEF in obese participants (42), but these findings are controversial as others have found no difference between obese and normal weight individuals. Findings by Granata suggest that methodological discrepancies between studies make comparisons of results difficult. Together these results suggest that there are not significant differences in energy expenditure and metabolic measurements between overweight/obese women with and without BED. Additionally, there was no difference in body composition between groups and no change in body composition over the two weeks of DLW sample collection within either group.

Similar results were reported Alger in a study of nine women with BED and nine obese controls who underwent 8 days of *ad libitum* eating and then 4 days of a weight maintenance diet in a laboratory setting. Measurements of 24-hour energy expenditure, respiratory quotient, resting metabolic rate and sleeping metabolic rate were performed in a respiratory chamber on the final day of each eating period. Consistent with our findings, no differences in metabolic measures were observed between BED and control participants even after adjusting for fat-free mass, fat mass and age (43). Since there was no change in body weight or composition, we can assume that TDEE is equal to energy intake and examine accuracy of self-reported food intake below.

In clinical practice and weight loss programs, many still rely on the HBE to estimate energy requirements. We calculated daily energy expenditure using the HBE and compared it to TDEE measured by the DLW method. The HBE substantially underestimated measured TDEE in this sample by ~23% and 24% in the BED and control groups, respectively. Estimates of predicted energy expenditure calculated using the HBE should be interpreted with caution given this discrepancy. Further research is needed to validate the utility of the HBE as an estimate of energy expenditure in overweight/obese and eating disordered individuals. Equations may need to be adjusted for accurate prediction of energy requirements for the overweight/obese population.

A second objective of this study was to assess differences in energy intake between groups. In the current study, the BED group ate significantly more on binge days than on non-binge

days and more than controls. There was no difference between BED non-binge days and average daily consumption by controls. There was a trend toward the BED group consuming more kilocalories on average than the controls as assessed by 24-hour recall (BED = 2,586.9 kcal, SD = 640.1, Control = 2,140.0 kcal, SD = 659.1, $F(1,32) = 4.032$, $p = .053$) but not according to food log data. These discrepant results are likely due to the 24 h recalls being a more accurate account of food intake than the food log entries (24-h recall estimates were closer to TDEE as determined by DLW). An alternative explanation could be that the BED group had preferentially not included binge eating episodes in their food logs. However, this is unlikely given the average number of binge dayes in the BED group was 7.5 in the food log data. It is also important to note that the BED group consumed significantly more kilocalories per BMI unit than did the control group adding additional support to the finding of higher daily caloric intake in the BED group.

Researchers have reported mixed results with regard to comparisons of total energy consumed by BED participants and controls. In our previous study, utilizing dietary recall interviews we did not demonstrate a difference in average reported intake between a group of women with BED (n = 12, m = 2,710 kcal, SD = 713) and matched controls (n = 8, m = 2,424 kcal, SD = 546) (18). However, we found that those with BED consumed significantly more calories on days they had a binge eating episode than controls consumed on average (BED = 3,395, SD = 568, Control = 2,424, SD = 546, $p = 0.002$). Rossiter et al. (17), reported significantly higher average daily intake on binge days than on binge free days (2,400 vs. 1,500 kcals) assessed by self-monitored food records for a group of women with non-purging bulimia who had an average BMI of 33. These women would likely have met current criteria for BED. Algers's group (43) reported that there were no differences in dietary composition or intake between women with BED and obese controls (BED = 2,587, SD = 454 kcals, controls = 2,386, SD = 201 kcals). A limitation of all of these studies is the small samples sizes. Based on a power analysis we conducted using data from Alger's study, they would have needed 39 participants in each group for 80% power to detect statistical differences between group means. In the current study, the mean difference between total daily intake in the BED and control groups was associate with a moderate effect size (Cohen's $d = 0.688$, moderate effect size $d > 0.5$, large effect size $d > 0.8$). Although these studies were underpowered, the directionality of findings in the current data and literature cited above is the same, with BED groups consuming more kilocalories than obese controls.

Our results and the literature review above raise important questions. If there are no differences between the BED and control groups metabolically and the BED group consumes more energy than the control group then over time the BED group should gain more weight. However, we did not find any statistically significant differences in body composition between baseline measures and the 2-week follow-up. If the BED group is actually consuming more energy and the TDEE is not different from controls then it is possible that our method of measuring change in body composition was not sensitive enough to detect increases in body mass over the 2-week period or we did not have enough power to statistically support such differences between groups. The test-retest differences for duplicate measures on the DXA scanner was <2%, with the ability to detect changes as low as 0.6kg (s.d. =0.023) (44). The change in kg over the 2-week collection period for the BED group was +0.033 (s.d. = 1.62) and for the control group was −0.671 (s.d. = 1.66) which was not statistically different between groups. Additionally, our post hoc power to detect a mean difference of this magnitude between groups at an α-level of 0.05 was 31.2%. Given the body composition change in this sample was within the confidence limits of the DXA scanner and the limited power to detect changes over a small time period, further research is needed to confirm that indeed BED is associated with higher overall caloric intake and weight gain. In a 2009 review of BED Wonderlich et al., concluded that "support for the idea that BED or binge eating predicts weight gain or negative medical outcomes is both

limited and mixed" (pg. 692). However, the authors note that the largest study in their review did suggest a relationship between binge eating and weight gain (45). Our results are consistent with the conclusions drawn by Wonderlich et al.

A third objective was to determine the accuracy of caloric intake as assessed by dietary recall interview and food log data. This was done by comparing recorded intake with measured energy expenditure (TDEE) obtained from the DLW method. Since there was no change in body weight or composition as assessed by DXA during the 14 days of doubly water collection, we can assume that energy intake was equal to TDEE. BED participants reported caloric intake that was 80% of TDEE according to dietary recall data and 68% of TDEE according to food log data. Control participants reported caloric intake that was 70% and 73% of TDEE according to dietary recall and food log data, respectively. There were no significant differences between groups by either method. Reports comparing recorded intake in obese individuals to energy expenditure measured by the DLW method suggest that most report intake that is ~60% of predicted expenditure (19,20). Although the expected 60% accuracy was within our 95% confidence region, our estimates on average were greater. It is possible that our BED and control groups reported intake with greater accuracy as a result of the dietary recall interviews that the women participated in prior to collecting the self-reported food log data. The dietary recall interviews involved a detailed discussion of food intake and portion sizes with expert interviewers. Additionally, participants were required to watch a food record training video immediately before to the two weeks of food log data collection. These activities may have trained participants in monitoring food consumption, leading to increased accuracy when recording intake in a food log later in the project. This may account for our groups reporting a higher percentage of TDEE than the 60% seen in most studies.

Yanovski and Sebring compared energy intake to estimated energy expenditure calculated by the HBE. They found that their BED participants reported 94% of predicted intake compared to obese controls who reported 64% of predicted intake. Possible explanations for greater energy intake in the Yanovsky BED group relative to controls include greater accuracy in reporting, increased metabolic requirements, and increased intake prior to starting a very low calorie diet as part of the study protocol. Our results do not support increased accuracy or metabolic requirements in BED participants. Therefore, it seems most likely the higher percentage of energy intake relative to predicted expenditure was due to increased intake and disinhibition prior to starting the very low calorie diet. In the current study, BED and non-BED obese reported 93% and 91% of predicted intake calculated by HBE, respectively. Our participants may have reported similar percentages because they were not about to enter a diet program. Additionally, the training on collection of dietary intake influenced our results as discussed above. Furthermore, it must be clarified that in Yanovski's study TDEE was estimated using HBE rather than measured by the DLW method as in the current study. As discussed above, our results suggest that HBE estimates of energy expenditure substantially underestimate TDEE.

Strengths of our study include the multiple methods used to assess energy intake and the use of the gold standard doubly labeled water method to assess energy expenditure. Additionally, statistical testing for group differences was not confounded by age or BMI. These factors are known to affect metabolic measures and the absence of group differences in age or BMI strengthened the ability to interpret findings. Although the size of the sample is larger than much of the previous work in this area, it is still a limitation of this study. A larger sample size may have clarified the issue of whether there is a significant difference in average daily intake between those with BED and controls. A further limitation is the lack of inclusion of data on physical activity due to participant noncompliance and technical issues

with monitors. Although BED is more common in females, another limitation is the lack of inclusion of men. Future studies should include both sexes.

In summary, a major positive finding of this study is that regardless of the method used to assess intake, both the BED and obese control groups clearly underestimate their caloric consumption. It is also interesting to note that there is greater disparity in daily caloric intake between the two methods in the BED group than in the controls. However, both groups reported fewer kcal than required to maintain their current weight since the reported intake was less than the TDEE by both methods of assessment. Thus the main positive finding in our study was well summarized by Lichtman et al in their1992 article in which they compared TDEE using DLW with reported intake, “The failure of some obese subjects to lose weight while eating a diet they report as low in calories is due to an energy intake substantially higher than reported and an overestimation of physical activity, not the abnormality in thermogenesis” (35).

The findings of our group and others repeatedly demonstrate increased intake on binge days compared to non-binge days in BED women. This distinguishes those with BED from typical obesity and lends further support to the diagnostic utility of BED and its inclusion in the upcoming DSM-V. We will explore differences in meal patterning and eating disordered behavior and attitudes in more detail in subsequent publications on data from these participants. More research is needed to explore the physiological and psychological basis of the binge eating episodes to facilitate effective prevention and treatment efforts.

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REFERENCES

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. JAMA. Jan 20; 303(3):235–241. [PubMed: 20071471]
2. Spitzer RL, Devlin MJ, Walsh BT, Hasin D, Wing R, Marcus MD. Binge eating disorder: a multisite field trial of the diagnostic criteria. Int J Eat Disord. 1992; 11:191–203.
3. de Zwaan M, Mitchell J, Seim HC, Specker SM, Pyle RL, Raymond NC, Crosby RB. Eating related and general psychopathology in obese females with binge eating disorder. Int J Eat Disord. 1994; 15(1):43–52. [PubMed: 8124326]
4. Adami GF, Gandolfo P, Campostano A, Cocchi F, Bauer B, Scopinaro N. Obese binge eaters: metabolic characteristics, energy expenditure and dieting. Psychol Med. 1995 Jan; 25(1):195–198. [PubMed: 7792355]
5. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 3rd ed. rev. ed.. Washington, DC: Author; 1987.
6. Dymek MP, le Grange D, Neven K, Alverdy J. Quality of life and psychosocial adjustment in patients after Roux-en-Y gastic bypass: a brief report. Obes Surg. 2001; 11:32–39. [PubMed: 11361166]
7. Hsu LK, Bentacourt S, Sullivan SP. Eating disturbances before and after vertical banded gastroplasty: a pilot study. Int J Eat Disord. 1996; 19:23–34. [PubMed: 8640199]
8. Kalarachian MA, Wilson GT, Brolin RE, Bradely L. Binge eating in bariatric surgery patients. Int J Eat Disord. 1998; 23:89–92. [PubMed: 9429923]

9. Sarwer DB, Cohn NI, Gibbons LM, et al. Psychiatric diagnoses and psychiatric treatment among bariatric surgery candidates. Obes Surg. 2004; 14:1148–1156. [PubMed: 15527626]
10. Saunders R. Binge eating in gastric bypass before surgery. Obes Surg. 1999; 9:72–76. [PubMed: 10065590]
11. Yanovski SZ, Sebring NG. Recorded food intake of obese women with binge eating disorder before and after weight loss. Int J Eat Disord. 1994 Mar; 15(2):135–150. [PubMed: 8173559]
12. Goldfein JA, Walsh BT, LaChaussee JL, Kissileff HR, Devlin MJ. Eating behavior in binge eating disorder. Int J Eat Disord. 1993 Dec; 14(4):427–431. [PubMed: 8293024]
13. Guss JL, Kissileff HR, Devlin MJ, Zimmerli E, Walsh BT. Binge size increases with body mass index in women with binge-eating disorder. Obes Res. 2002 Oct; 10(10):1021–1029. [PubMed: 12376583]
14. Raymond NC, Bartholome LT, Lee SS, Peterson RE, Raatz SK. A comparison of energy intake and food selection during laboratory binge eating episodes in obese women with and without a binge eating disorder diagnosis. Int J Eat Disord. 2007 Jan; 40(1):67–71. [PubMed: 17080451]
15. Sysko R, Devlin MJ, Walsh BT, Zimmerli E, Kissileff HR. Satiety and test meal intake among women with binge eating disorder. Int J Eat Disord. 2007 Sep; 40(6):554–561. [PubMed: 17534911]
16. Yanovski SZ, Leet M, Yanovski JA, Flood M, Gold PW, Kissileff HR, et al. Food selection and intake of obese women with binge-eating disorder. Am J Clin Nutr. 1992 Dec; 56(6):975–980. [PubMed: 1442665]
17. Rossiter EM, Agras WS, Telch CF, Bruce B. The eating patterns of non-purging bulimic subjects. Int J Eat Disord. 1992; 11:111–120.
18. Raymond NC, Neumeyer B, Warren CS, Lee SS, Peterson CB. Energy intake patterns in obese women with binge eating disorder. Obes Res. 2003 Jul; 11(7):869–879. [PubMed: 12855757]
19. Black AE, Prentice AM, Goldberg GR, Jebb SA, Bingham SA, Livingstone MB, et al. Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. J Am Diet Assoc. 1993 May; 93(5):572–579. [PubMed: 8315169]
20. Westerterp KR, Goris AH. Validity of the assessment of dietary intake: problems of misreporting. Curr Opin Clin Nutr Metab Care. 2002 Sep; 5(5):489–493. [PubMed: 12172471]
21. Harris, JA.; Benedict, FG. A Biometric Study of Basal Metabolism in Man. Washington: Carnegie Institution of Washington; 1999.
22. Bandini LG, Schoeller DA, Edwards J, Young VR, Oh SH, Dietz WH. Energy expenditure during carbohydrate overfeeding in obese and nonobese adolescents. Am J Physiol. 1989 Mar; 256(3 Pt 1):E357–E367. [PubMed: 2646945]
23. Diaz EO, Prentice AM, Goldberg GR, Murgatroyd PR, Coward WA. Metabolic response to experimental overfeeding in lean and overweight healthy volunteers. Am J Clin Nutr. 1992 Oct; 56(4):641–655. [PubMed: 1414963]
24. Klein S, Goran M. Energy metabolism in response to overfeeding in young adult men. Metabolism. 1993 Sep; 42(9):1201–1205. [PubMed: 8412776]
25. Coward WA. Stable isotopic methods for measuring energy expenditure. The doubly-labelled-water (2H2(18)O) method: principles and practice. Proc Nutr Soc. 1988 Sep; 47(3):209–218. [PubMed: 3076004]
26. Coward WA, Ritz P, Cole TJ. Revision of calculations in the doubly labeled water method for measurement of energy expenditure in humans. Am J Physiol. 1994 Dec; 267(6 Pt 1):E805–E807. [PubMed: 7810619]
27. American Psychiatric Association. Diagnostic and statistical manual of mental disorders : DSM-IV-TR. 4th ed. Washington, DC: American Psychiatric Association; 2000. Task Force on DSM-IV.
28. Hartman AM, Brown CC, Palmgren J, Pietinen P, Verkasalo M, Myer D, et al. Variability in nutrient and food intakes among older middle-aged men. Implications for design of epidemiologic and validation studies using food recording. Am J Epidemiol. 1990 Nov; 132(5):999–1012. [PubMed: 2239915]

29. Bartholome LT, Raymond NC, Lee SS, Peterson CB, Warren CS. Detailed analysis of binges in obese women with binge eating disorder: Comparisons using multiple methods of data collection. Int J Eat Disord. 2006 Dec; 39(8):685–693. [PubMed: 16937383]
30. Schoeller DA, Leitch CA, Brown C. Doubly labeled water method: in vivo oxygen and hydrogen isotope fractionation. Am J Physiol. 1986 Dec; 251(6 Pt 2):R1137–R1143. [PubMed: 3538910]
31. Speakman JR. The history and theory of the doubly labeled water technique. Am J Clin Nutr. 1998 Oct; 68(4):932S–938S. [PubMed: 9771875]
32. Coward WA, Roberts SB, Cole TJ. Theoretical and practical considerations in the doubly-labelled water (2H2(18)O) method for the measurement of carbon dioxide production rate in man. Eur J Clin Nutr. 1988 Mar; 42(3):207–212. [PubMed: 3133206]
33. Cole TJ, Coward WA. Precision and accuracy of doubly labeled water energy expenditure by multipoint and two-point methods. Am J Physiol. 1992 Nov; 263(5 Pt 1):E965–E973. [PubMed: 1443129]
34. Harris AJ, Benedict FG. A Biometric Study of Human Basal Metabolism. Proc Natl Acad Sci U S A. 1918; 4(12):370–373. [PubMed: 16576330]
35. Lichtman SW, Pisarska K, Berman ER, Pestone M, Dowling H, Offenbacher E, et al. Discrepancy between self-reported and actual caloric intake and exercise in obese subjects. N Engl J Med. 1992 Dec 31;327(27):1893–1898. [PubMed: 1454084]
36. Platte P, Pirke KM, Wade SE, Trimborn P, Fichter MM. Physical activity, total energy expenditure, and food intake in grossly obese and normal weight women. Int J Eat Disord. 1995 Jan; 17(1):51–57. [PubMed: 7894453]
37. Prentice AM, Black AE, Coward WA, Davies HL, Goldberg GR, Murgatroyd PR, et al. High Levels of Energy Expenditure in Obese Women. Br Med J (Clin Res Ed). 1986; 292:983–987.
38. Buhl KM, Gallagher D, Hoy K, Matthews DE, Heymsfield SB. Unexplained disturbance in body weight regulation: diagnostic outcome assessed by doubly labeled water and body composition analyses in obese patients reporting low energy intakes. J Am Diet Assoc. 1995 Dec; 95(12):1393–1400. quiz 401–2. [PubMed: 7594141]
39. Butte NF, Treuth MS, Mehta NR, Wong WW, Hopkinson JM, Smith EO. Energy requirements of women of reproductive age. Am J Clin Nutr. 2003 Mar; 77(3):630–638. [PubMed: 12600853]
40. Kempen KP, Saris WH, Westerterp KR. Energy balance during an 8-wk energy-restricted diet with and without exercise in obese women. Am J Clin Nutr. 1995 Oct; 62(4):722–729. [PubMed: 7572699]
41. Weber JL, Reid PM, Greaves KA, DeLany JP, Stanford VA, Going SB, et al. Validity of self-reported energy intake in lean and obese young women, using two nutrient databases, compared with total energy expenditure assessed by doubly labeled water. Eur J Clin Nutr. 2001 Nov; 55(11):940–950. [PubMed: 11641742]
42. Granata GP, Brandon LJ. The thermic effect of food and obesity: discrepant results and methodological variations. Nutr Rev. 2002 Aug; 60(8):223–233. [PubMed: 12199298]
43. Alger S, Seagle H, Ravussin E. Food intake and energy expenditure in obese female bingers and non-bingers. Int J Obes Relat Metab Disord. 1995 Jan; 19(1):11–16. [PubMed: 7719385]
44. Levine JA, Eberhardt NL, Jensen MD. Role of nonexercise activity thermogenesis in resistance to fat gain in humans. Science. 1999; 283:212–214. [PubMed: 9880251]
45. Wonderlich SA, Gordon KH, Mitchell JE, Crosby RD, Engel SG. The validity and clinical utility of binge eating disorder. Int J Disord. 2009; 42:687–705.

Table 1

Descriptive statistics and group differences in demographics, energy expenditure and energy intake measures.

BED/Control (n=BED/n=Control)	BED Mean (SD)	Control Mean (SD)	F	p
Age (years) (17/17)	30.8 (7.2)	31.7 (8.5)	0.107	0.745
BMI (kg/m2) (17/17)	34.8 (6.0)	35.2 (6.9)	0.019	0.891
TDEE (15/14)	3213.9 (552.8)	3171.8 (525.3)	0.044	0.835
TEF (15/14)	35.4 (20.0)	29.7 (21.4)	0.534	0.472
BMR (15/14)	1607.7 (246.8)	1628.1 (336.8)	0.035	0.853
24-hour Recall (Kcals) (17/17)	2586.9 (640.1)	2140.0 (659.1)	4.023	0.053
24-hour Recall (Kcals/BMI)(17/17)	76.2 (23.4)	61.0 (14.2)	5.268	0.030
Food Log (Kcals) (14/16)	2234.4 (386.0)	2185.0 (535.4)	0.082	0.777
Food Log (Kcals/BMI)(14/16)	67.5 (17.4)	62.6 (14.0)	0.707	0.408

BED, binge eating disorder; BMR, basal metabolic rate; TDEE, total daily energy expenditure; TEF, thermic effect of food.

Table 2

Comparison of caloric intake on BED binge days with nonbinge days and with control data

BED Binge day	BED Non-Binge days	Controls	BED Binge vs. control		BED Non-Binge vs. Control	
Mean (SD) n	Mean (SD) n	Mean (SD) n	F	p	F	p
		24-hour Recall				
3254.5 (520.0) 14	2233.4 (584.0) 17	2140.0 (659.1) 17	26.429	<0.0001	0.191	0.665
		Food Log				
2983.0 (432.6) 11	1972.1 (305.0) 14	2185.0 (535.4) 16	16.815	<0.0001	1.721	.200

BED, binge eating disorder

Table 3

Comparison of caloric intake on BED binge days with BED nonbinge days

BED Mean (s.d.) n		Binge day vs. nonbinge day	
Binge days	Non binge days	F	P
24-hour Recall			
3,254.5 (520.0) 14	2,343.1 (556.6)	26.429	<0.0001
Food log			
2,983.0 (432.6) 11	1,972.5 (343.7) 11	16.815	<0.0001

BED, binge eating disorder

Table 4

Descriptive statistics and group differences in energy expenditure versus reported intake

BED/Control (n=BED/n=Control)	BED Mean (SD)	Control Mean (SD)	F	p
24-hour Recall/TDEE (15/14)	0.797 (0.23)	0.675 (0.25)	1.885	0.181
Food Log/TDEE (15/13)	0.702 (0.19)	0.725 (0.24)	0.081	0.778
HBE (15/14)	1759.5 (175.4)	1790.7 (257.4)	0.148	0.704
PER (15/14)	2375.3 (236.8)	2417.5 (347.5)	0.148	0.704
PER/TDEE (15/14)	0.757 (0.14)	0.774 (0.12)	0.121	0.731

BED, binge eating disorder; HBE, Harris–Benedict equation; PER, predicted energy requirements based on HBE and light activity; TDEE, total daily energy expenditure.