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Cognitive Function in Morbidly Obese Individuals With and Without Binge Eating Disorder

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Abstract

Objective—Obesity is associated with poorer cognitive function and impulsivity, which may contribute to binge eating disorder (BED). The objective of this study was to compare cognitive function in morbidly obese individuals with and without BED.

Method—A total of 131 morbidly obese individuals (41 with past or present BED, 90 with no BED history) completed a computerized battery of cognitive tests including executive, memory, language, and attention.

Results—Both groups of participants evidenced high rates of cognitive impairment, however, no significant differences emerged between persons with and without BED on cognitive testing. Comparison of persons without BED, current BED, and past BED also yielded no differences.

Discussion—In the present sample, morbidly obese individuals with and without BED were clinically indistinguishable on tests of cognitive function. Our findings suggest that obesity, rather than binge eating, may be more directly related to cognition. Future studies should further examine this relationship, as it might provide greater insight into the neural mechanisms for this BED.

Binge eating disorder (BED) involves the consumption of an objectively large amount of food with an associated loss of control over eating, in the absence of extreme compensatory weight control behaviors [1]. BED occurs in about 2% of the general population and up to

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30% of those in weight loss treatment programs [2]. Persons with BED are more likely to be obese and have elevated rates of mental health comorbidities, including suicide attempts [3–5].

Loss of control is believed to play a central role in BED [6] and empirical studies show increased impulsivity in this population [6–7]. Such findings suggest the presence of neurocognitive dysfunction in persons with BED, particularly in frontal brain regions. For example, a recent study found persons with binge eating tendencies show differential activity in these regions on functional MRI relative to those without binge eating [8].

Few studies have compared neuropsychological test performance in persons with and without BED and the results remain unclear [9–11]. In two studies, obese individuals with BED performed more poorly on tests of executive function than persons without BED [9] and overweight women with BED showed impairment in decision making compared to overweight women without BED [10]. However, another study found that obese individuals with and without BED demonstrated impairment on decision-making tasks compared to normal weight controls but did not differ from each other [11]. Frontal brain regions are known to mediate the executive functions, a broad set of mental abilities that include impulse control, self-monitoring and planning [12]. However, while previous studies focused on executive function, attention abilities are also largely mediated by frontal brain regions [13] and executive dysfunction can also lead to deficits in learning and recall [14]. Given the possibility that BED might be associated with deficits in multiple cognitive abilities, we compared morbidly obese individuals with and without BED on a broad set of neuropsychological tests to assess functioning in attention, executive function, memory, and language. Based on the above, we hypothesized that individuals with BED would perform more poorly on tests of all cognitive domains including executive function, attention, memory and language.

METHODS

All procedures were approved by the appropriate Institutional Review Boards and all participants provided written informed consent prior to study involvement.

Trial Design and Participants

Participants of this study included 131 individuals who were recruited from the Longitudinal Assessment of Bariatric Surgery (LABS) parent project, and all participants were recruited from three existing LABS sites (Columbia, Cornell, and the Neuropsychiatric Research Institute). Inclusion criteria included age between 20–70 years and being English-speaking. Exclusion criteria included a history of neurological disorder or injury (e.g. dementia, stroke, seizures), moderate to severe head injury (defined as > 10 minutes of loss of consciousness [15]), past or current history of alcohol or drug abuse (DSM-IV criteria)[1], history of a learning disorder or developmental disability (defined by DSM-IV criteria)[1], or impaired sensory function. The average age of participants was 42.0 years and 87.2% of the sample was female. BMI ranged from 32.8 to 75.0 with a mean value of 45.0. Of the participants in this sample, 66.1% were bariatric surgery candidates.

The presence of somatic complaints including diabetes and hypertension was assessed using patient self report and corroboration with medical records. The presence of axis I disorders, including BED, was assessed using a structured clinical interview for the DSM-IV Axis I disorders (SCID-I [16]). Participants were categorized into those with and without a lifetime history of BED. For additional analyses, the SCID-I was used to classify those who met criteria for BED at the initial measurement from those who had met criteria in the past, and those without a history of BED.

Measures

The Integneuro computerized cognitive test battery estimates intellectual abilities and assesses performance in multiple cognitive domains. Raw scores for each measure were transformed into z-scores based on age, gender, and estimated IQ to promote generalizability and facilitate clinical interpretation. Tests were categorized into four domains: Memory, Attention, Executive Function and Language. These tests included:

Memory

Verbal list-learning—Participants are read a list of 12 words a total of 4 times and asked to recall as many words as possible following each trial. Following presentation and recall of a distraction list, participants are asked to recall words from the original list. After a 20-minute delay, participants are asked to recall target words. Finally, a recognition trial comprised of target words and foils is completed. The four dependent variables generated from this task are the z-scores for total learning (sum of words recalled on all learning trials), short delay free recall, long delay free recall, and recognition.

Attention

Digit span backward—Digit span assesses basic auditory attention. Participants are presented with a series of digits on the touch-screen, separated by a one-second interval. Participants are then immediately asked to enter the digits on a numeric keypad on the touch-screen in the reverse order of presentation. The number of digits in each sequence is gradually increased from 3 to 9, with two sequences at each level. The dependent measure for this task is the z-score for total number of correct trials.

Span of visual memory—This task is similar to Spatial Span from the Wechsler Memory Scales [15]. Participants are asked to re-create highlighted forward and backward patterns on the screen. The dependent measure for this task is the z-score for total number of correct trials.

Switching of Attention- Digits—This test is a computerized adaptation of the Trail Making Test A [16]. Participants are presented with a pattern of 25 numbers in circles and asked to touch them in ascending order. This test assesses attention and psychomotor speed. The z-score for time to completion is used as the dependent variable.

Verbal Interference - Word—This subtest is similar to the Word trial on the Stroop Color Word Test [17]. Participants are presented with color words one at a time. Below each colored word is a response pad with the 4 possible words displayed in black and in a fixed format. Participants are required to identify the name of each word as quickly as possible after it has been presented on the screen, providing a measure of attention. The test lasts for 1 minute. The dependent variable is the z-score for number of words correctly identified.

Executive Attention

Switching of attention – Digits and Letters—This test is a computerized adaptation of the Trail Making Test B [18]. Participants are presented with an array of 13 numbers (1–13) and 12 letters (A–L). Participants are asked to touch numbers and letters alternately in ascending order. This test taps both attentional abilities and executive function. The z-score for time to completion is used as the dependent variable.

Verbal Interference- Color—This subtest is similar to the Color Word trial of the Stroop Color Word Test [19]. The participants are presented with colored words one at a time. To measure executive function, the subject is required to name the color of the ink rather than

the target word as quickly as possible. Each part lasts for 1 minute. The dependent variable is the z-score for number of words correctly identified.

Maze task—The maze task assesses executive function and is a computerized adaptation of the Austin Maze [20]. Participants are presented with an 8×8 matrix of circles and are asked to identify the hidden path through the grid. Unique auditory and visual cues are presented for correct and incorrect responses. When participants have completed the maze twice without error, or after 10 minutes has passed, the trial ends. The two dependent variables used for this study are the z-scores for total number of errors and total number of overruns committed.

Language

Letter Fluency—For the letter fluency task, participants are asked to generate words beginning with a given letter of the alphabet (F, A, and S), for 60 seconds. The z-score for total number of correct words generated summed across all three trials is the dependent variable.

Animal Fluency—For the animal fluency task, participants are asked to generate as many animal names as they can in 60 seconds. The z-score for total number of correct animal names is the dependent variable.

Statistical Analysis

A series of analyses were conducted to examine possible cognitive differences between morbidly obese persons with and without BED. First, chi-square analyses determined whether participants with and without BED differed in the prevalence of clinical impairment (i.e. >1.5 SD below normative values). To further clarify possible differences in clinical impairment, the total number of impaired tests was summed for each individual and a t-test examined possible between-group differences. Finally, multivariate analyses of variance (MANOVA) was performed to investigate differences between groups in each of the four cognitive domains (Memory, Attention, Executive Function and Language). MANOVA was then used to investigate differences between those with current, past and no history of BED. Significant omnibus tests were clarified using Bonferroni-corrected post hoc tests.

RESULTS

Demographic and Medical Characteristics

Of the 131 participants in our sample, 41 met criteria for a lifetime history of either sub-threshold BED or full BED. The average age of the sample was 42 years ($SD = 10.8$) and average BMI was 45.0 ($SD = 6.42$). Independent samples t-tests and chi-squares found no differences in age, BMI, sex, sleep apnea, diabetes, hypertension, current major depressive disorder, current generalized anxiety disorder or current bulimia nervosa. See Table 1.

No Differences in Prevalence of Clinical Impairment

Clinically-meaningful levels of cognitive impairment (>1.5 SD below normative values) were common both in participants with BED (range 2.4–19.5%) and those without BED (4.4–18.9%). Chi-square analyses found no significant differences in impairment on any of the tests between those with and without a history of BED (See Table 2). A t-test comparing the number of impaired test performances was not significant [$t(61.38) = -.935$, $p = 0.35$]. See Table 2.

No Between-Group Differences in Test Performance

Using MANOVA, no significant differences were found on any domain between those with and without a history of BED including memory ($\lambda = .98$, $F(4, 120) = .48$, $p > .05$), attention ($\lambda = .94$, $F(4, 117) = .188$, $p > .05$), executive function ($\lambda = .98$, $F(4, 120) = .485$, $p > .05$), or language ($\lambda = .97$, $F(2, 122) = 2.19$, $p > .05$). See Table 3.

No Differences Between Current, Past and No History of BED

Further analyses investigated whether differences existed between those who currently met criteria for BED ($n = 16$), those with a history of BED ($n = 26$) and those with no history of BED ($n = 90$). Using MANOVA, no differences were found on any domain (memory ($\lambda = .984$, $F(8, 240) = .34$, $p > .05$), attention ($\lambda = .914$, $F(8, 234) = 1.34$, $p > .05$), executive function ($\lambda = .932$, $F(8, 240) = 1.08$, $p > .05$) or language ($\lambda = .962$, $F(4, 244) = 1.19$, $p > .05$)). See Table 4.

DISCUSSION

The goal of the current study was to examine possible cognitive test differences in a sample of morbidly obese persons with and without BED. Eating disorders such as anorexia nervosa and bulimia nervosa have long been associated with neurocognitive deficits [21–23] and a two recent studies found persons with BED demonstrate reduced performance on tests of executive function [9,10]. While both groups evidenced high rates of cognitive impairment, no differences in executive function emerged between those with and without BED. Further, no differences were found in any other cognitive domain, despite multiple analytic approaches. Several aspects of these results warrant brief discussion.

These findings are in opposition to expectations based upon previous research on eating disorders and cognitive function. Cognitive dysfunction across multiple domains has been well documented among other eating disorder groups [6–8, 21–23]. An inability to control impulses is a central feature of BED, strongly implicating deficits in executive function as an important factor in this disorder [7]. Previous research has produced mixed results on executive dysfunction in overweight and obese persons with BED compared to overweight and obese controls [9–11]. The present study detected no differences in any cognitive domain in a sample of morbidly obese persons with and without BED.

The exact reason for the inconsistent findings among previous research and the current findings are unclear. The results of this study are similar to a previous study in which obese individuals with and without BED performed worse on decision-making tasks compared to normal weight controls but did not differ from each other [11]. However, two other studies found that those with BED performed worse than individuals without BED [9, 10]. One possible explanation for this difference is BMI. Our sample and the sample which found no differences between those with and without BED had a higher average BMI ($M = 45.0$ and 37.2 respectively) [11] than earlier work ($M = 35.6$) [9] and ($M = 31.72$) [10] and there is evidence that BMI has a linear association with neurocognitive outcomes [24, 25]. It is possible that greater overall cognitive difficulty is present in the samples with higher BMIs, masking more subtle group differences. Another possibility is that there may be differences between individuals with grade 1 and 2 obesity. In the current sample, only two individuals were classified as having grade 1 obesity which eliminated the possibility of analysis between the two grades. Finally, Duchesne et al (2010) and Davis et al. (2010) excluded individuals with conditions with the potential to influence cognitive function (e.g. major depression, diabetes) and individuals greater than 45 years of age, whereas such persons were retained in the current study and in Svaldi et al. (2010). Although our approach provides for greater generalizability and representation of typical patient groups, it is

possible that the association between BED and cognitive function is obscured by comorbid conditions.

A final possible explanation involves measurement and statistical approaches. The present study used clinically focused measures of executive function while previous research employed experimental tasks. It is possible that the tasks used in the other studies are more sensitive to differences. The current study employed a conservative approach to identify possible differences between morbidly obese persons with and without BED, utilizing z-scores for test performance and analytical approaches that aggregate test scores within a given domain. It is possible that the more liberal use of raw scores and individual test scores in past work may help to account for the differences. Much additional work in this area is needed to clarify the possible association between BED and poor neurocognitive outcome. Such findings may inform the conceptualization of factors promoting the development, maintenance, and treatment of BED. For example, BED has been widely considered a disorder of impulse control which suggests executive dysfunction. However, our study does not support this association, suggesting that the current conceptualization of BED may be missing important aspects of the disorder. It is noteworthy that both groups exhibited poor cognitive performance relative to normative data. As such our data suggest that while obesity is significantly associated with cognitive impairment, the relationship between BED and cognitive status remains less clear.

The present study is limited in several ways. An important limitation is the use of cross sectional data. It is possible that an age by BED interaction exists on cognitive function or that weight status moderates the association between BED and cognitive function. To our knowledge, no study has examined the effect of age on cognition in individuals with eating disorders, and most studies on eating disorders focus on the young adult population. Work from our group demonstrates that cognitive function improves after bariatric surgery [26]. Prospective studies are needed to investigate the impact that age and duration of disorder, and weight loss may have on cognition. Another limitation of this study is the possibility that candidates for bariatric surgery who may have otherwise been diagnosed with BED, minimized or denied symptoms due to fear that they would be prevented from undergoing the procedure. This might lead to more subtle differences between the groups due to incorrect classification of groups. Another limitation involves the criteria for BED. Although we used the SCID to ensure reliable assessment, the conceptualization of BED is less well established than some other forms of eating pathology. Using a SCID diagnosis alone may not be sufficient to categorize our two groups and it is possible that a more dimensional approach might yield differential findings. For example, adding dimensional components to the diagnosis of BED would allow for the inclusion of those who have feature of the disorder but do not meet full criteria and for the differentiation of those with BED based on the severity of the disorder [27,28] allowing for investigation of within-group differences in cognition among those with BED. Another important limitation is that the present study did not have measures that directly assessed decision making or inhibitory control. Future studies should re-examine the relationship between impulse control and BED in a morbidly obese sample using direct measures of impulse control. A final limitation is the possibility that the nonsignificant findings may reflect Type II error. However, this likelihood is relatively small, given the very small effect sizes between groups (e.g. $d = 0.070$ for Total Learning) and fact that BED participants performed better on some tests (e.g. Learning, Short Delay Recall, Digit Span Backward, FAS words).

In summary, we found no cognitive test differences in morbidly obese persons with and without BED. Further work in this area is much needed, particularly prospective studies involving neuroimaging, as the neural underpinnings of BED may help to provide key insight into the mechanisms for this disorder.

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Table 1

Demographic and Medical Characteristics of Morbidly Obese Persons with and without BED

	BED (N = 41)	No BED (N = 90)	Test Statistic	p
Age (41.2, 10.4)	43.58 +/- 11.45	41.18 +/- 10.40	$t = -1.04$, df = 97	0.30
BMI (45.0, 6.42)	45.40 +/- 6.12	44.87 +/- 6.58	$t = -0.42$, df = 123	0.67
Female (75, 87.2%)	96.3	83.1	$\chi^2 = 2.19$, df = 1	0.09
Sleep Apnea (38, 29.5%)	70.0	76.1	$\chi^2 = 0.26$, df = 1	0.61
Diabetes (29, 22.5%)	77.5	81.8	$\chi^2 = 0.21$, df = 1	0.65
Hypertension (62, 48.4%)	57.5	67.0	$\chi^2 = 0.38$, df = 1	0.54
Current Major Depressive Disorder (8, 13.3%)	16.7	10.0	$\chi^2 = 0.39$, df = 1	0.54
Current Generalized Anxiety Disorder (1, 1.2%)	0.0	3.3	$\chi^2 = .268$, df = 1	0.61
Current Bulimia Nervosa (1, 1.0%)	8.3	0.0	$\chi^2 = 3.07$, df = 1	0.08

Note: BMI- body mass index, t-statistic (t) provided for age and BMI, Chi-square (χ^2) provided for all other statistics

Table 2

Impairment (n, %) on Each Individual Test for Those with and without BED

	BED (N = 41)	No BED (N = 90)	$\chi^2(1)$	p
Memory				
Total Learning	6, 14.6	17, 18.9	0.35	0.55
Short Delay Recall	5, 12.2	10, 11.1	0.03	0.86
Long Delay Recall	5, 12.2	9, 10.0	0.14	0.71
Recognition Accuracy	8, 19.5	15, 16.7	0.16	0.69
Attention				
Digit Span Backward	1, 2.4	3, 3.3	0.08	0.78
Span of Visual Memory	8, 19.5	10, 11.1	1.68	0.20
Switching of Attention (digits)	7, 17.1	7, 7.8	2.55	0.11
Verbal Interference (Word)	4, 9.8	3, 3.3	2.30	0.13
Executive Function				
Switching of Attention (mixed)	4, 9.8	5, 5.6	0.78	0.38
Verbal Interference (Color)	6, 14.6	7, 7.8	1.48	0.22
Maze Errors	8, 19.5	11, 12.2	1.21	0.27
Maze Overruns	6, 14.6	17, 18.9	.035	0.55
Language				
FAS words	5, 12.2	13, 14.4	0.12	0.73
Animal names	4, 9.8	4, 4.4	1.39	0.24

Note: $\chi^2(1)$ – Chi-Square statistic with one degree of freedom

Table 3

Z-scored test performance (M,SD)for each individual test for those with and without BED.

Tests	BED	No BED	F(1)	Sig.
Memory				
Total Learning	−0.47 (1.49)	−0.56 (1.07)	0.15	0.70
Short Delay Recall	−0.19 (1.19)	−0.33 (1.01)	0.49	0.48
Long Delay Recall	−0.24 (1.09)	−0.25 (1.01)	0.00	0.96
Recognition Accuracy	−0.78 (1.08)	−0.70 (1.00)	0.16	0.69
Attention				
Digit Span Backward	0.11 (1.78)	−0.11 (1.10)	0.52	0.47
Span of Visual Memory	−0.30 (1.22)	−0.08 (1.20)	0.48	0.49
Switching of Attention (digits)	−.078 (1.52)	0.58 (1.31)	6.05	0.02
Verbal Interference (Word)	0.12 (1.24)	0.38 (1.16)	1.41	0.24
Executive Function				
Switching of Attention (mixed)	0.11(1.18)	0.31 (1.40)	0.59	0.44
Verbal Interference (Color)	0.20(1.38)	0.56 (1.37)	1.82	0.18
Maze Errors	−.031 (1.30)	−.017 (1.40)	0.31	0.58
Maze Overruns	−0.05 (1.52)	0.12 (1.94)	0.22	0.64
Language				
FAS words	−0.04(1.08)	−0.35 (1.16)	2.02	0.16
Animal names	−.07 (1.16)	0.07 (1.04)	0.46	0.50

Table 4

Z-scored Test Performance current, past, no history of BED

Tests	Current BED (N = 16)	Past BED (N = 26)	No BED (N = 90)	F	Sig.
Memory					
Total Learning	−0.63(1.78)	−0.38(1.29)	−0.55(1.07)	0.24	0.78
Short Delay Recall	−0.19(1.32)	−0.20(1.10)	−0.33(1.01)	0.20	0.82
Long Delay Recall	−0.35(1.24)	−0.20(1.01)	−0.24(1.01)	0.10	0.91
Recognition Accuracy	−1.30(1.09)	−0.51(0.98)	−0.69(0.99)	3.11	0.05
Attention					
Digit Span Backward	0.41(1.09)	−0.13(1.22)	−0.13(1.09)	1.45	0.24
Span of Visual Memory	−0.64(0.94)	−0.07(1.07)	0.01(1.06)	2.44	0.09
Switching of Attention (digits)	−0.30(1.56)	0.04(1.49)	0.62(1.34)	3.84	0.02
Verbal Interference (Word)	−0.02(1.29)	0.22(1.21)	0.37(1.16)	0.74	0.48
Executive Function					
Switching of Attention (mixed)	−0.31(1.30)	0.36(1.02)	0.33(1.42)	1.60	0.21
Verbal Interference (Color)	0.56(1.11)	0.03(1.49)	0.54(1.37)	1.44	0.24
Maze Errors	−0.54(1.35)	−0.17(1.26)	−0.14(1.42)	0.52	0.60
Maze Overruns	−0.11(1.42)	−0.01(1.57)	0.15(1.94)	0.17	0.84
Language					
FAS words	−0.05(1.33)	−0.05(0.91)	−0.00(1.17)	0.82	0.44
Animal names	0.10(1.13)	−0.15(1.17)	0.11(1.09)	0.55	0.58

Note: Values provided are z-scored means (SD)