ORIGINAL ARTICLE

Cognitive dysfunction predicts poorer emotion recognition in bariatric surgery candidates

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Summary

Objective

Deficits in traditional cognitive domains (e.g. executive function and memory) are common in persons with severe obesity, but it is unclear if this pattern of dysfunction extends to social cognition. The present study examined whether cognitive impairment was associated with poorer emotion recognition in bariatric surgery candidates.

Methods

One hundred sixteen bariatric surgery candidates (mean age = 43.62 ± 11.03; 81% female) completed the computerized Integneuro test battery as part of a larger study visit. In addition to assessing traditional cognitive domains, the Integneuro also includes an emotion recognition measure. This task presents 48 faces (eight different individuals depicting neutral, happiness, fear, sadness, anger and disgust), and participants must choose the correct verbal label from six expression options. Number of correct responses and average reaction time for correct responses served as primary dependent variables.

Results

Stepwise multiple regression analyses revealed that older age, more maze errors, and history of hypertension predicted less accuracy in emotion recognition (adjusted $R^2 = .22$, $F[3, 111] = 11.86$, $p < .001$) and that slower switching of attention-digits, worse long-delay recall, and older age predicted speed of responses (adjusted $R^2 = .26$, $F[3, 111] = 13.00$, $p < .001$).

Discussion

Results show that cognitive dysfunction is associated with poorer performance on a computerized test of emotion recognition, consistent with those in persons with a range of psychiatric and neurological disorders. Additional work is needed to clarify the mechanisms and functional impact of these impairments, especially in relation to weight loss following bariatric surgery.

Keywords: Bariatric surgery, cognitive function, emotion recognition, obesity.

Introduction

Obesity is a growing health epidemic, with prevalence rates above 34% in adults and 16% in youth as of 2011–2012 (1). Obesity is a risk factor for many health problems, including cardiovascular disease, stroke, type 2 diabetes and cancer (2). Recent work has shown that obesity is also linked to poor neurocognitive outcomes. For example, studies demonstrate an association between midlife obesity and increased risk of dementia (3–6). Persons with obesity also exhibit neuropsychological deficits, such as poorer performance on measures of memory and executive function, even before the onset of dementia (7–10).

Such findings raise the possibility that obesity also has negative effects on other mental processes. Growing evidence suggests that obesity is associated with deficits in recognizing emotions in others and oneself. Children with obesity and their mothers show difficulties in discriminating the nonverbal emotional expressions of others compared with their normal weight peers (11). Further, women with obesity, when compared with women of normal weights, were found to have a reduced awareness of their own emotions in addition to the emotions of others (12). Perhaps related to these difficulties, obesity is associated with an approximately 25% increase in lifetime prevalence of mood and anxiety disorders, including major depression (13). Research on the mental processes associated with these conditions shows abnormalities in emotion recognition (14,15), including over-perceiving negative affect in ambiguous facial expressions (15).

No study has examined whether obesity is related to difficulties on an emotion recognition task or the extent to which these deficits are attributable to underlying cognitive dysfunction. The current study examined this possibility in a sample of individuals with severe obesity and hypothesized that the degree of impairment in emotion recognition would be related to that found in traditional cognitive domains (e.g. memory and executive function).

Materials and methods

All methods were approved by the Institutional Review Board at each site, and all participants provided written informed consent prior to participating in any study activities.

Participants

A total of 116 bariatric surgery candidates were included in the current study. All participants were part of the Longitudinal Assessment of Bariatric Surgery (LABS) parent project and recruited from LABS sites (Columbia, Cornell, and Neuropsychiatric Research Institute). For study inclusion, participants were required to be enrolled in LABS, between 20 and 70 years of age and English-speaking. Exclusion criteria included past or current history of neurological disorder or injury (e.g. dementia, stroke and seizures), moderate or severe head injury (defined as >10 min loss of consciousness (16)), severe psychiatric illness (e.g. schizophrenia and bipolar disorder), alcohol or drug abuse (defined by Diagnostic and Statistical Manual of Mental Disorders, 4th Edition [DSM-IV] criteria), learning disorder or developmental disability (defined by DSM-IV criteria) or impaired sensory function.

Consistent with this methodology, study participants had severe obesity (mean body mass index (BMI) = 46.29 ± 6.42) and many had histories of hypertension (54.3%), type 2 diabetes (27.0%) and sleep apnoea (39.7%). Their mean age was 43.62 ± 11.03 years of age, and 81% were female. For sample characteristics, see Table 1.

Measures

All participants completed a computerized test battery that included measures of cognitive function and emotion recognition. The Integneuro test battery has excellent psychometric properties (17,18), takes approximately 45–60 min to complete and is sensitive to cognitive impairments in persons with elevated BMI and bariatric surgery candidates (19–22). Specific measures are discussed in the succeeding texts.

Emotion recognition

This validated measure (23,24) asks individuals to correctly identify the emotion associated with a presented facial expression as quickly as possible. A total of 48 targets are presented, using the emotion expressions validated in past work (25). Specifically, target expressions include neutral and evoked depictions of happiness, fear, sadness, anger and disgust that are presented in

Table 1 Characteristics and cognitive test performance of 116 bariatric surgery patients

Age (years)	43.62 ± 11.03
Gender (% female)	81%
BMI	46.29 ± 6.42
Hypertension	54.3
Type 2 diabetes	27.0
Sleep apnoea	39.7
Hx of anxiety disorder	32.8
Hx of depressive disorder	50.9
Emotion recognition	
Hits (out of 48)	33.28 ± 3.86
Reaction time for correct (s)	2.09 ± 0.45
Cognitive tests (*t* scores)	
Attention	
Digit span – forward	58.67 ± 10.30
Switching of attention – numbers	54.24 ± 13.81
Visual interference – word	52.45 ± 12.82
Executive function	
Switching of attention – letter/number	52.91 ± 14.29
Visual interference – colour word	54.82 ± 13.64
Maze errors	44.11 ± 13.19
Maze overruns	52.25 ± 18.12
Memory	
Learning	42.85 ± 12.54
Long-delay free recall	45.38 ± 10.64
Language	
Animal naming	50.54 ± 10.67

pseudorandom order. Numbers of correct hits (out of 48) and reaction time (RT) for correct responses were used as dependent variables.

Cognitive tests

To promote generalizability, test scores on the traditional cognitive tests were converted to *z* scores (mean = 0, standard deviation = 1) based on existing normative data using age, gender and estimated intelligence quotient through the Integneuro.

Digit span forward

This test assesses basic auditory attention. Participants are presented with a series of digits on the touch-screen, separated by a 1-s interval. The subject is then immediately asked to enter the digits on a numeric keypad on the touch-screen. The number of digits in each sequence is gradually increased from three to nine, with two sequences at each level. The dependent measure is the total number of correct trials forward.

Switching of attention

This test is a computerized adaptation of the Trail Making Test (24) and consists of two parts. In the first part, participants are presented with a pattern of 25 numbers in circles and asked to touch them in ascending order. In the second part, an array of 13 numbers (1–13) and 12 letters (A–L) is presented. Participants are asked to touch numbers and letters alternately in ascending order. The first part of this test assesses attention and psychomotor speed, whereas the second part taps these abilities as well as executive function. Time to completion for each test is used as the dependent variable.

Verbal interference

This task taps the ability to inhibit automatic and irrelevant responses and is comparable to the Stroop Colour Word Test (26). Participants are presented with coloured words one at a time. Below each coloured word is a response pad with the four possible words displayed in black and in fixed format. The test has two parts. In part 1, the subject is required to identify the name of each word as quickly as possible after it is presented on the screen, thus providing a measure of attention. In part 2, the subject is required to name the colour of each word as quickly as possible, assessing executive functioning. Each part lasts for 1 min. The dependent variable will be the number of words correctly identified in each trial.

Maze task

This task is a computerized adaptation of the Austin Maze (Walsh, 1985) and assesses executive function. Participants are presented with a grid (8 × 8 matrix) of circles and asked to identify the hidden path through the grid. Distinct auditory and visual cues are presented for correct and incorrect responses. The trial ends when the subject completes the maze twice without error or after 10 min has elapsed. The dependent variable is the number of total errors and maze error overruns (i.e. preservative errors) on the task.

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-min filled delay, participants are again asked to recall target words. Finally, a recognition trial comprised of target words and foils is completed. Four dependent variables are generated from this task, specifically Total Learning (sum of words recalled on all learning trials), Short-Delay Free Recall, Long-Delay Free Recall, and Recognition.

Animal fluency

Participants are asked to generate as many animal names as possible in 60 s. Total correct serves as the dependent variable.

Procedures

Persons enrolled in the parent LABS project at selected sites (Columbia University Medical Center, Cornell University Medical Center, and Neuropsychiatric Research Institute) were approached regarding their possible interest in taking part in the current study. After providing written informed consent, participants completed self-report instruments and the computerized cognitive test battery within the 30 days prior to surgery. Medical records were reviewed by research staff to corroborate and supplement participant self-report.

Statistical analyses

The possible relationship between emotion recognition and cognitive test performance in bariatric surgery candidates was analysed through several steps. Pearson and bivariate correlations were used to explore the association between emotion recognition and patient characteristics (e.g. demographic and medical) and cognitive test performance. Stepwise multiple regression with forward entry was then performed to determine which factors contribute to emotion recognition in this population.

Results

Relationship between emotion recognition and patient factors

Correlation analyses revealed that the number of hits on the emotion recognition task was associated with age (r = -0.39) and performance on the maze task (Maze Errors, $r = 0.34$; Maze Errors Overruns, $r = 0.31$; $p < 0.01$ for all).

In terms of average RT for correct items, correlation analyses found close relationships with age ($r = 0.28$) and history of hypertension ($r = -0.26$), as well as performance on measures of attention (switching of attention – numbers, r = -0.34), executive function (switching of attention – letter/number, $r = -0.28$; Maze Overruns, $r = -0.26$), memory (Long-Delay Free Recall, $r = -0.33$) and language (animal naming, $r = -0.25$) (Table 2).

Predictors of accuracy on emotion recognition test

Stepwise multiple regression with forward entry was then used to predict the number of hits on the emotion recognition test. Being the first study to examine these processes in bariatric surgery candidates, all above demographic and cognitive variables were entered as possible predictors. Results showed that age ($\beta = -0.43$), Maze Errors (measure of executive function; $\beta = 0.27$) and history of hypertension ($\beta = -0.21$) predicted hits ($R = 0.49$, $R^2 = 0.24$) (Table 3).

Predictors of reaction time on emotion recognition test

Stepwise multiple regression with forward entry was then used to predict reaction rime for correct responses on the emotion recognition test. Switching of attention – numbers (measure of attention; $\beta = -0.30$), long-delay free recall (measure of memory; $\beta = -0.27$) and age ($\beta = 0.24$) predicted reaction time ($R = 0.51$, $R^2 = 0.26$) (Table 4).

Discussion

Results from the current study demonstrate that both demographic and cognitive variables are associated with emotion recognition in bariatric surgery candidates. Interestingly, performance on tests of attention, executive function and memory were all found to be significant predictors of emotion recognition accuracy or speed.

As may be expected, medical and demographic factors were found to be predictors of poorer emotion recognition. Older age predicted more mistakes as well as slowed RT on the emotion recognition task. These results are unsurprising, as age is a well-established predictor of decline in traditional cognitive domains, such as memory, processing speed, reasoning and executive functions (27,28), and has previously been associated with impaired emotion recognition in healthy older adults (29–31). Uncontrolled blood pressure is also an established predictor of accelerated cognitive decline (32,33) and linked to executive dysfunction through structural changes to frontal brain regions (34). These same areas have been suggested as points of integration for emotion recognition information from other neural systems (35) and the current findings may reflect this shared pathway.

In the current study, poorer performance on a test of executive function (i.e. number of errors in completing a maze task) was associated with reduced accuracy in emotion recognition. A likely explanation is found in the mediation of both abilities by frontal brain regions, which

Table 2 Correlations between emotion recognition and patient characteristics and cognitive test performance

	Hits	RT
Age	−.39**	.28**
Gender	.04	−.16
BMI	.18*	−.02
Hypertension	.04	−.26**
Type 2 diabetes	.12	−.03
Sleep apnoea	.14	−.20*
Hx of anxiety disorder	−.15	−.11
Hx of depressive disorder	−.13	.01
Cognitive tests		
Attention		
Digit span – forward	.08	−.04
Switching of attention – numbers	.15	−.34**
Visual interference – word	.01	−.22*
Executive function		
Switching of attention – letter/number	.20*	−.28**
Visual interference – colour word	.13	−.06
Maze errors	.34**	−.15
Maze overruns	.31**	−.26**
Memory		
Learning	.16	−.23*
Long-delay free recall	.13	−.33**
Language		
Animal naming	.02	−.25**

Note: The numbers of correct hits (accurately identified emotional expressions, out of 48) and reaction time for correct responses (measured in seconds) were used as dependent variables.
*p < 0.05;
**p < 0.01.

Table 3 Predicting accuracy of emotion recognition in bariatric surgery patients using patient characteristics and cognitive tests

Included variables	β	p	
Age	−0.43	<0.001	
Maze errors	0.27	0.002	
Hypertension	−0.21	0.03	
		$R^2 = 0.24$	
		Adjusted $R^2 = 0.22$	
		$R = 0.49$	
Excluded variables	**β**	**p**	**Partial correlation**
BMI	0.16	0.06	0.18
Gender	−0.04	0.67	−0.04
Learning	0.08	0.36	0.09
Digit span forward	−00.02	0.86	−0.02
Switching of attention – numbers	0.04	0.64	0.04
Switching of attention – letter/number	0.08	0.41	0.08
Visual interference – word	−0.06	0.51	−0.06
Visual interference – colour eord	0.07	0.39	0.08
Animal naming	−0.03	0.71	−0.04
Maze overruns	−0.03	0.85	−0.02
Hx of anxiety	−0.10	0.24	−0.11
Hx of depression	−0.10	0.22	−0.12
Type 2 diabetes	0.03	0.71	0.04
Sleep apnoea	0.02	0.83	0.02

Table 4 Predicting reaction time of correct responses of emotion recognition in bariatric surgery patients using patient characteristics and cognitive test

Included variables	β	p	
Switching of attention – numbers	−0.30	<0.001	
Long-delay free recall	−0.27	0.001	
Age	0.24	0.005	
		$R^2 = 0.26$	
		adjusted $R^2 = 0.24$	
		$R = 0.51$	
Excluded variables	**β**	**p**	**Partial correlation**
BMI	0.04	0.62	0.05
Gender	−0.04	0.65	−0.04
Learning	0.13	0.27	0.11
Digit span forward	0.04	0.64	.05
Switching of attention – letter/number	−0.03	0.76	−0.03
Visual interference – word	−0.09	0.31	−0.10
Visual interference – colour word	0.06	0.47	0.07
Animal naming	−0.08	0.40	−0.08
Hx of anxiety	−0.11	0.21	−0.12
Hx of depression	−0.01	0.95	−0.01
Hypertension	−0.12	0.23	−0.11
Type 2 diabetes	0.08	0.37	0.09
Sleep apnoea	−0.17	0.06	−.18

contribute to executive processes necessary for both the maze task and the decision-making portion of the emotion recognition task (35-39), although additional work is needed to confirm this possibility. Similarly, slower performance on a measure of complex attention (i.e. switching of attention-digits) was associated with a longer delay in correctly identifying the target emotion. Psychomotor slowing is commonly found in persons with elevated BMI (40), and these findings raise the possibility that it may have consequences in recognizing emotions and ultimately interpersonal interactions for this population.

The exact mechanism(s) for the relationship between delayed free recall on a memory test and emotion recognition is less clear, although deficits in emotion recognition have previously been observed in patient populations with memory impairment. For example, patients with Alzheimer's disease exhibit deficits in emotion recognition (41,42), potentially due to the deterioration of limbic structures that negates the advantages for remembering emotional stimuli over neutral stimuli (43). Individuals with amnestic mild cognitive impairment also exhibit reduced emotion recognition, although to a lesser extent and with fewer emotions than persons with Alzheimer's disease (44). Given the heightened risk of pathological cognitive decline in individuals with obesity (45-47), prospective studies are needed to determine the possible prognostic value of emotion recognition in this population.

The present study is limited in several ways that should be considered when interpreting these findings. Although the emotion recognition task employed has been used in past research (23,24), subtle differences in methodology across such tasks limit the ability to generalize and compare results (48,49). Normative data do not exist for most emotion recognition tasks, and further research on task performance would facilitate interpretation and provide context for the current findings. Additionally, the ecological validity of emotion recognition tasks using static images of facial expressions rather than spontaneous expressions has been questioned, with some evidence for important differences between the two (50–52). Further, the present sample size of 116 is relatively small, and confirmation of the current findings in larger samples is much needed. Finally, this study only includes individuals with severe obesity, and future studies including a broad range of BMI and expanded assessments of emotion recognition will further clarify these relationships.

In brief summary, the present study found that cognitive dysfunction was associated with poorer emotion recognition in individuals with severe obesity. If confirmed in future studies, such findings raise the possibility that neuropsychological function in this population may be linked to a wide range of poor outcomes, including psychiatric conditions and social consequences.

Conflict of Interest

No conflict of interest was declared.

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