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Cognitive Function is Linked to Adherence to Bariatric Postoperative Guidelines

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Abstract

Background—Impairment in cognitive function is found in a significant subset of individuals undergoing bariatric surgery and recent work shows this impairment is associated with smaller postoperative weight loss. Reduced cognitive function could contribute to poorer adherence to postoperative guidelines, though this has not been previously examined.

Objectives—The current study examined the relationship between cognitive function and adherence to bariatric postoperative guidelines. We expected that higher cognitive function would be associated with better adherence to postoperative guidelines.

Setting—Data were collected through the bariatric service of a major medical center.

Methods—Thirty-seven bariatric surgery patients completed cognitive testing and a self-report measure of adherence to postoperative bariatric guidelines during their 4–6 week postoperative appointment.

Results—Strong correlations were observed between adherence to postoperative guidelines and cognitive indices of attention, executive function, and memory.

Conclusions—Results demonstrate that cognitive performance is strongly associated with adherence to postoperative guidelines shortly after bariatric surgery. Further work is needed to clarify if this relationship is present at later postoperative stages, and the degree to which this relationship mediates postoperative weight loss outcomes.

Keywords

adherence; memory; cognition; executive function; bariatric surgery

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Introduction

Although bariatric surgery leads to successful weight loss for most patients, longitudinal work suggests a substantial minority (up to 30%) fail to lose weight, or regain a significant amount of weight over time.[1] Many predictors for suboptimal postoperative weight loss have been identified, including demographic, medical, and psychosocial factors.[2–7]While multiple contributors to suboptimal weight loss have been identified, successful intervention remains elusive; efforts to enhance postoperative weight loss success yield mixed results.[8–9]

Recent work suggests another likely contributor to suboptimal weight loss following bariatric surgery is cognitive impairment. Obese individuals are known to demonstrate poorer attention, executive function, and memory relative to normal weight controls.[10,11] In bariatric surgery samples, clinically significant cognitive impairment is present in up to 23% of patients, with 40% demonstrating more subtle deficits.[12] Extending this work, recent research demonstrates that preoperative baseline cognitive impairment predicts weight loss outcome at one year.[13] However, the manner in which cognitive function contributes to weight loss outcomes is not entirely clear. A likely explanation involves reduced adherence to postoperative guidelines.

Bariatric surgery requires multiple postoperative lifestyle changes in diet, eating behavior, and physical activity.[14,15] Little research has examined the role of adherence in predicting weight loss outcomes, though cognition is linked to adherence in other medical populations, including type 2 diabetes,[16] hypertension,[17] and heart failure.[18] In the bariatric surgery population, one study[4] found that self-reported dietary adherence and cognitive restraint at postoperative week 20 predicted weight loss at week 92. Similarly, increased levels of disinhibition predict weight regain in both the bariatric and behavioral weight loss populations.[19] It is possible that such findings involving restraint and disinhibition may actually reflect broader impairment in executive function, which includes higher order cognitive abilities, such as ability to inhibit, organize, and plan.[20] In combination with deficits in other areas of cognitive function known to be reduced in this population (i.e., attention, memory), these impairments could limit the bariatric surgery patient's ability to plan healthy meals, resist impulses to eat tempting foods, schedule physical activity, recall complex eating behavior recommendations, or even fully attend to the advice of clinical staff during appointments.

Despite these links, no previous work has investigated if cognitive function is associated with adherence to postoperative bariatric guidelines. The current study examined the relationship between cognitive function and self-reported adherence in patients approximately 1 month following laparoscopic Roux-en-Y gastric bypass surgery (LRYGB). We hypothesized that poorer cognitive test performance would be linked to reduced adherence to postoperative guidelines.

Materials and Methods

Trial Design and Participants

A total of 37 bariatric surgery patients were recruited during their 1 month (range= 4–6 weeks) postoperative follow-up appointment. Inclusion criteria included having undergone LRYGB, being between 18–65 years of age and English-speaking. Exclusion criteria included history of neurological disorder or injury (e.g. dementia, stroke, seizures), moderate or severe head injury (defined as >10 minutes loss of consciousness[21]), past or current history of severe or poorly controlled psychiatric illness, history of learning disorder or developmental disability, or impaired sensory function that precluded cognitive testing

(e.g., poor visual acuity preventing the participant from responding to computerized tasks). Only patients having completed the LRYGB procedure were recruited, as surgery types vary in postoperative weight loss outcomes and recommendations, and LRYGB is the most common procedure utilized at the performance site. Medical history was obtained via medical record review.

Participants ranged in age from 23 to 65 years old (M = 46.92, SD = 11.08). Of the sample, 65.8% were female. BMI at baseline ranged from 32.95 to 64.50 (M = 45.59, SD = 7.43). Of the sample, 80.6% were Caucasian and 19.4% were African American. The average number of years of education was 14.49 (SD = 2.23) and ranged from 10 to 18 years. Postoperative complications included 5 participants with nausea/vomiting, 2 with infection, 1 experiencing mild stricture (resolved after 2 dilations), and 1with anemia and respiratory insufficiency. All complications were resolved by the time of testing for the current study.

Interventions and Clinical Follow-Up

All procedures were approved by the appropriate Institutional Review Boards. All participants provided written informed consent prior to study involvement. Participants attending their 1 month (range = 4–6 weeks) LRYGB postoperative appointment were approached in the waiting room by research or clinical staff about their interest in participating in this research project. This appointment was chosen as it is a surgical visit with a particularly high attendance rate (93.2%), optimizing opportunity to capture a range of adherence. Interested individuals were explicitly informed that participation was voluntary and could be discontinued at any time, that their information would be collected in a de-identified manner, would not be reviewed by clinical care providers except in aggregate, and would not affect their medical care. Patients providing consent were given a $10 gift card as payment for their time and participation. Participants then completed computerized cognitive testing and a self-report bariatric surgery postoperative adherence measure. Total time to completion was approximately 30–45 minutes. Following completion of the participant's data collection, medical records were reviewed by study staff and medical, psychiatric, and surgical history extracted on a de-identified basis.

All participants received similar preoperative instructions which include a preliminary informational seminar, a binder of written materials (e.g., phases of the diet, vitamin and supplement recommendations, prohibition against smoking and NSAIDS, etc.), a minimum of 2 preoperative visits with the dietitian, an online educational video on their surgery, and nurse education as part of the informed consent procedure. Patients may have received additional education if indicated or if their insurance mandated additional dietitian visits (e.g., a 6 month diet). Postoperatively, patients in this program are seen by their surgeon 1 week after surgery. At 4–6 weeks postoperatively, they are seen again by their surgeon and attend shared nutrition and psychology appointments. At 3 months, patients attend shared medical, nutrition and psychology appointments. At 6 and 9 months patients see medicine and nutrition. A 1 year, they see their surgeon, dietitian and psychologist again. Patients are seen by the team annually thereafter or on an as needed basis.

Adherence Self-Report

The Bariatric Surgery Self-Management Questionnaire (BSSQ[22] is a 33-item questionnaire regarding adherence to prescribed behaviors specific to bariatric surgery. This measure asks about adherence during the previous week in the following seven domains: eating behaviors (8 items), physical activity (3 items), dumping syndrome management (4 items), and intake of fluids (8 items), supplements (4 items), fruits/vegetables/whole grains (3 items), and protein (3 items). The BSSQ utilizes a Likert-type scale format of "never," "sometimes," or

"always." Subscales for each domain are calculated, as well as a total score (0–99 range), with higher scores indicating greater adherence.

Cognitive Test Battery

The WebNeuro cognitive test battery is a web-based, abbreviated form of the IntegNeuro computerized cognitive test battery, which has been used in several previous studies of cognition in obesity[10,11] and bariatric surgery.[12,13] This test battery demonstrates good psychometric properties and is comparable to (though briefer than) the IntegNeuro test battery.[23] It consists of estimated premorbid intellectual abilities as well as performance in cognitive domains most sensitive to deficits in this population (i.e., Attention, Executive Function, Memory) and is completed in approximately 30 minutes. All scoring is done at a central facility by highly trained researchers. Specific tests utilized include: Spot-the-Word asks individuals to distinguish a valid word in the English language (“true” target word) from a non-word foil to render an estimated intelligence quotient. Total correct score is entered into a regression formula including education and age to estimate intelligence quotient. This estimate is strongly correlated with the Wechsler Adult Intelligence Scale (r >.80).[24]

Choice Reaction Time. On this task, circles are displayed on the screen, and the participant must closely watch for a target circle to be illuminated in pseudorandom sequence over a series of trials. For each trial, the participant is required to use the mouse to click on the illuminated circle as quickly as possible, providing a measure of speeded attention. The dependent variable is the mean reaction time across trials.

Verbal Interference taps ability to inhibit automatic and irrelevant responses and is adapted from the Stroop Color Word Test.[25] The test has two parts: In part 1, participants identify the name of each word as quickly as possible; total number of errors was used in the attention index. In part 2, they quickly identify the color of the ink in which each word is printed, inhibiting the word reading response; total number of errors in this task was utilized in the executive function index.

Mazes. This task is a computerized adaptation of the Austin Maze[26] in which 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 completed the maze twice without error or after 10 minutes has elapsed. Total number of errors and overruns were used in the executive function index.

Verbal List-learning displays a list of 12 words a total of 4 times. After each trial, the participant must identify as many words as possible from a recognition list comprised of target words and foils. After a 10-minute filled delay, participants are again asked to recognize target words. The memory index combined total number correct and total number of errors from the delayed recognition trial.

Data Analyses

To facilitate clinical interpretation and maintain directionality within scales, all raw scores of neuropsychological measures assessing cognitive function were transformed to z-scores (a distribution with a mean of 0, and a standard deviation of 1) using existing normative data correcting for age and gender. A composite score for each domain (memory, attention, and executive function) was created by averaging the z-scores from each of the specific tests within that domain. Partial correlations controlling for estimated intellectual function (Spot-the-Word score) were conducted to examine the associations among domains of cognitive

function (memory, attention, and executive function) and the subscales of the BSSQ adherence measure. Percent weight loss (%WL) was calculated using standard methods.

Results

Cognitive Impairment is Prevalent among Bariatric Surgery Patients

Clinically significant cognitive impairment (>1.5SD below the mean) was seen in 5.3% of individuals in each domain (i.e., 5.3% of the sample demonstrated impairment in memory, 5.3% in attention, and 5.3% in executive function). Only one participant exhibited clinically significant impairment in more than 1 domain, and no participants demonstrated impairment in all 3 domains, suggesting that no participants exhibited global impairment across measures. Subclinical cognitive impairment (>1.0SD below the mean) was seen in 18.4% of individuals in memory, 10.5% in attention and 7.9% in executive function. Significant variability was seen within the sample, with the Attention composite scores ranging from −2.63 to 0.56, Executive Function composite ranging from −2.34 to 1.27, and Memory composite scores ranging from −2.71 to 0.90.

Non-Adherence is Prevalent Among Bariatric Surgery Patients

Rates of non-adherence to bariatric postoperative guidelines self-reported on the BSSQ are high (see Table 1). Reduced adherence was particularly common for eating behavior (e.g. eating 5 mini-meals/snacks daily, drinking at least 48 ounces of appropriate liquids daily, eating 5 serving of fruits or vegetables daily, and eating recommended amounts of protein daily; these ranged from 51–84% of the sample in non-adherence) and physical activity (e.g. 30–60 min physical activity 5 days per week, building exercise into daily routines, and building weight training into regular exercise; these ranged from 43–89% of the sample in non-adherence).

Cognitive Function is Associated with Adherence

Partial correlational analyses were used to examine the relationship between cognitive function and adherence after controlling for estimated intelligence (Spot-the-Word score). Memory was significantly associated with total BSSQ score ($r = -.35$, $p = .04$) and vitamin and mineral supplement intake ($r = -.56$, $p < .001$). Executive function was significantly associated with physical activity ($r = -.35$, $p = .04$) and protein intake ($r = -.34$, $p = .05$). Attention was significantly associated with physical activity ($r = -0.37$, $p = .03$).

High Rates of Weight Loss among Bariatric Surgery Patients

Average %WL was 11.24% (SD =2.84), and ranged from 6.60% to 16.18%. BMI lost ranged from 2.19 to 9.56 ($M = 5.20$, $SD = 1.69$). Participants lost an average of 15.20 kg ($SD = 5.60$ kg); weight loss ranged from 7.26 to 31.03 kg.

Postoperative Weight Loss and Adherence, Cognition

%WL was not significantly associated with total BSSQ ($r = .21$, $p = .22$), or any of the subcategories of physical activity ($r = -.11$, $r = .52$), vitamin and mineral supplement intake ($r = .31$, $p = .06$), protein intake ($r = .21$, $p = .20$), eating behaviors ($r = .09$, $p = .62$), fluid intake ($r = .05$, $p = .62$), dumping syndrome management ($r = .16$, $p = .37$). %WL was also not associated with attention ($r = .04$, $p = .80$), executive function ($r = -.03$, $p = .88$), or memory ($r = -.02$, $p = .90$).

Discussion

The current results show that better cognitive function is associated with higher levels of reported adherence to postoperative guidelines in bariatric surgery patients during the early postoperative stage. These relationships raise the possibility that cognitive function plays an important role in bariatric surgery outcomes. Several aspects of the current finding warrant brief discussion.

Consistent with past work, the current study found high rates of cognitive dysfunction in bariatric surgery patients. Up to 18.4% of participants from the current study exhibited subclinical or clinical levels of cognitive dysfunction on testing 4–6 weeks postoperatively. This number is lower than percent of cognitive impairment identified in preoperative samples,[12] and may be consistent with prior research demonstrating that bariatric surgery improves cognitive function.[12] While past work demonstrates this cognitive improvement at 12 weeks, the current study suggests benefit may occur even earlier, during more acute stages of recovery from bariatric surgery. Also similar to previous findings,[22] the current study finds rates of self-reported non-adherence are high, and appear to be particularly common in eating behavior and physical activity.

Non-adherence to postoperative guidelines was not only prevalent in the current study, but was also closely associated with cognitive dysfunction. This pattern is consistent with findings from other medical samples, including cardiovascular disease and type 2 diabetes.[16–18] It is not surprising that this relationship between adherence and cognitive function translates to the bariatric surgery population as well, given literature linking executive dysfunction to high calorie snack food intake and sedentary behavior.[27] Future studies should examine whether behavioral interventions used to improve adherence in persons with cognitive dysfunction can increase bariatric surgery patients' compliance to postoperative guidelines, including interventions utilizing newer technology (e.g., smartphones).

Neither cognitive function nor adherence was associated with weight loss at the 4–6 week postoperative visit used in the current study. This finding is perhaps not surprising given the recency of surgery. Weight loss in months immediately following surgery is nearly universal.[28] Thus, behavioral and cognitive factors are less likely to be predictive of these outcomes soon after surgery; these factors become much more important at long-term follow up, when greater variability in outcomes may be observed.[29] Similar to the current findings, recent work suggests that the relationship between cognition and weight loss may not emerge until many months following surgery.[13] It has been previously suggested that this lack of findings could be due to the robust effects of surgery alone in early weeks, or possibly to additional family and medical support.[13] Another consideration is that early postoperative confidence, self-efficacy, or enthusiasm might enhance adherence immediately following surgery.

The early postoperative appointment time was chosen for the current study to maximize the likelihood of capturing a range of adherence. A challenge in the study of adherence is that the individuals who are missing appointments may also be those least likely to adhere to other recommendations. Rates of attendance at the chosen appointment are particularly high (93.2%); given that nearly all patients attend this appointment, those demonstrating a greater range of adherence to other recommendations may be present. Although this highly attended timepoint may be missing data from the small percent of individuals at greatest risk for poor adherence, a later timepoint would likely have included even fewer non-adherent individuals, as these individuals may be more inclined to miss or fail to schedule recommended medical follow-up appointments. Importantly, despite potentially missing

data from the most non-adherent patients, we were still able to detect significant relationships.

However, while potentially maximizing a range of adherence behavior, the choice of an early postoperative appointment also limits the opportunity to detect a meaningful association between adherence and weight loss outcomes, given that some individuals could have difficulty fully adhering to some guidelines (e.g., achieving recommended amounts of physical activity, eating 5 meals per day) shortly after surgery. For example, rates of physical inactivity may be higher in early weeks following surgery due to recovery from physical effects of surgery. Similarly, individuals with significant nausea and vomiting may experience greater difficulty eating according to dietary recommendations. Of interest, we conducted the same analyses reported here excluding those individuals with postoperative complications such as nausea and vomiting, and this did not alter the nature of the relationships observed. Regardless, it is possible that this early timepoint captures higher levels of non-adherence than might be found at later postoperative timepoints.

Another important limitation is the reliance on self-report measures of adherence. Although this approach was able to capture problems with adherence, self-report measures are vulnerable to reporting bias. For example, a recent study examining pre- to postoperative changes in physical activity found small postoperative decreases in objectively measured physical activity, despite patient reports of a 5× increase.[30] A review by Thomas and colleagues[31] suggests that technological advancements allowing for objective or real-time monitoring, such as accelerometry and ecological momentary assessment, are better tools than questionnaires for assessing postoperative patient behavior. Finally, although adequate to detect the observed relationships, the relatively small sample of this preliminary study precludes advanced statistical techniques such as mediation/moderation analyses, which would be of particular interest.

Future studies should include longitudinal examination of cognition (i.e., pre- and postoperative, as well as over a more extended period of time), particularly given that cognition is known to improve shortly after surgery.[12] In light of the cross-sectional nature of the current study, it is not known whether pre- versus postoperative cognition better predicts adherence and outcomes. Similarly, given the current study's very early 4–6 week postoperative timepoint, longitudinal analyses would provide better understanding of how the relationship between cognitive function and adherence may change over time, as well as the relationship to long-term weight loss success or failure. The current study is unable to speak to these longer-term issues. Additionally, although we included only patients undergoing LRYGB in order to maintain homogeneity in weight loss and postoperative recommendations, the current findings would likely apply to other bariatric procedures. Future research should consider examining the relationships between cognition and adherence across surgery types.

Given that patients may not be motivated to accurately disclose non-adherence, more objective or "in the moment" measurement of adherence (e.g., accelerometer measurement of physical activity, ecological momentary assessment for behavior) may be of benefit to optimally understand the relationship between cognitive function and adherence. This type of measurement would better capture if the relationship between cognitive function and weight loss is mediated by adherence to postoperative guidelines. Finally, it will be necessary to examine other factors that may be involved in predicting weight loss outcomes. The current study does not seek to control for demographic, medical, and psychosocial factors that have been associated with postoperative weight loss outcomes[2–7]. Other unstudied factors may underlie the relationships observed in the current study, and effort

should be made to include such variables in future examination of cognitive function and adherence in this population.

Conclusions

Results of the current study demonstrate that poorer cognitive function is associated with reduced adherence to postoperative guidelines in bariatric surgery patients during the early postoperative period. Further work is needed to clarify if this relationship is present at later postoperative stages, as well as the degree to which this relationship mediates postoperative weight loss outcomes.

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Table 1

Rates of Self-Reported Non-Adherence to Postoperative Guidelines

Recommended Daily Behavior	% Patients Self-Reporting Non-Adherence
30–60 min physical activity 5 days per week	51.4%
Build exercise into daily routine	43.2%
Drink before feeling thirsty	24.3%
Eat 5 mini-meals/snacks per day	78.4%
Take 20–30 minutes to eat a meal	32.4%
Check if feeling full after each bite	35.1%
Drink 48 ounces or more per day	51.4%
Build weight training into daily routine	89.2%
Eat at least 5 fruits and vegetables per day	83.8%
Eat 60–80 g protein per day	54.1%

* Denotes guidelines which may be impacted by recency of surgery