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The Mini-Mental State Exam (MMSE) is not Sensitive to Cognitive Impairment in Bariatric Surgery Candidates

Rachel Galioto, M.A.¹, Sarah Garcia, M.A.¹, Mary Beth Spitznagel, PhD¹, Gladys Strain, PhD², Michael Devlin, MD³, Ross D. Crosby, PhD^{4,5}, James E. Mitchell, MD^{4,5}, and John Gunstad, Ph.D¹

¹Kent State University, Kent, OH

²Weill Cornell Medical College, Fargo, ND

³Columbia University College of Physicians and Surgeons, Fargo, ND

⁴Neuropsychiatric Research Institute, Fargo, ND

⁶University of North Dakota School of Medicine and Health Sciences, Fargo, ND

Abstract

Background—Cognitive dysfunction is common among bariatric surgery candidates and associated with poorer weight loss outcomes. Identification of a brief screening measure to detect cognitive impairment in this population is needed, as comprehensive neuropsychological evaluations may not be available in all clinical settings.

Setting—Longitudinal Assessment of Bariatric Surgery (LABS), United States; Medical Center

Methods—The current study examined the utility of the Mini-Mental State Examination (MMSE) for detecting cognitive impairment in 30 bariatric surgery candidates by comparing impairment on the MMSE (at varying cutoffs) to impairment on a comprehensive neuropsychological test battery.

Results—Results indicated that the MMSE showed low sensitivity and specificity in identifying impairment, even at the more stringent MMSE cutoffs of 27 and 28.

Conclusions—These findings suggest that the MMSE is a poor screener for cognitive impairment in bariatric surgery candidates. Future research is needed to identify or develop cognitive screeners for use in this population.

Keywords

Bariatric surgery; Cognitive function; Neuropsychological testing; Cognitive screening

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Please address all correspondence to: John Gunstad, Ph.D. Department of Psychology, Kent State University, Kent OH 44242, Telephone: 330.672.2589 jgunstad@kent.edu.

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Cognitive dysfunction is prevalent among bariatric surgery candidates, particularly in the areas of memory and executive function^(1–3). Recent findings show that 25% of bariatric surgery candidates exhibit clinically meaningful levels (> 1.5 SD below average) of cognitive impairment and up to 40% show more subtle impairments (> 1 SD below average) on neuropsychological testing⁽⁴⁾. Identification of these deficits may have important clinical implications in bariatric surgery patients, as cognitive function has recently been identified as a predictor of post-operative weight loss outcomes among bariatric surgery patients.⁽¹⁾ Specifically, research shows that pre-operative cognitive impairment is associated with poorer adherence and reduced weight loss at 12-month follow-up.^(1, 5)

Given the importance of cognitive function to clinical outcomes, pre-operative identification of cognitive impairment in bariatric surgery patients is important. However, in clinical practice, a thorough neuropsychological evaluation may not be available or practical for all patients, highlighting the need to identify a short screening test that is able to detect cognitive impairment among bariatric surgery candidates. A commonly used cognitive screener is the Mini-Mental State Examination (MMSE)⁽⁶⁾. The MMSE is widely used in a number of medical populations such as heart failure⁽⁷⁾, stroke⁽⁸⁾, and chronic obstructive pulmonary disease⁽⁹⁾ and is useful for detecting severe cognitive impairment and dementia.^(10–12) The aim of the current study was to examine the utility of the MMSE in detecting cognitive impairment among bariatric surgery candidates by comparing performance on neuropsychological testing to MMSE scores.

Methods

The following methods were approved by the IRB and all participants provided written informed consent. This project has been listed on clinicaltrials.gov.

Participants

Participants included 30 bariatric surgery candidates ($M_{age} = 41.4$, $SD = 11.93$; 70% female) recruited from the Longitudinal Assessment of Bariatric Surgery (LABS) project. Inclusion criteria included 20 to 70 years of age and English speaking. Exclusion criteria included history of neurological disorder or injury (e.g. dementia, stroke, seizures), history of moderate to severe head injury (more than 10 minutes of loss of consciousness⁽¹³⁾), past or current history of alcohol or drug abuse (DSM-IV criteria)⁽¹⁴⁾, history of a learning disorder or developmental disability (DSM-IV criteria)⁽¹⁴⁾, or impaired sensory function that precluded computerized testing. BMI ranged from 36.04 to 61.82 ($M_{BMI} = 47.16$, $SD = 7.34$). All procedures were approved by the appropriate Institutional Review Boards and all participants provided written informed consent prior to study involvement.

Measures

Cognitive Screening Measure—The MMSE⁽⁶⁾ is a 30-item, brief global cognitive screening measure. The MMSE is comprised of several short tasks used to assess a number of areas of cognitive function including attention, memory, language, and visuospatial abilities, as well as orientation to person, place and time. The published normative data for this test suggests a cutoff of 24 (23 and below) for detecting cognitive impairment. More

recent research has suggested that a cutoff of 27 or 28 is more useful in detecting more mild cognitive impairment^(15–16), which is what is more likely to be seen in this population^(4, 17–18).

Comprehensive Neuropsychological Test Battery—The Integneuro cognitive test battery is a standardized and semi-automated computerized battery that estimates intellectual abilities and assesses performance in multiple cognitive domains. Tests are administered in a fixed order using pre-recorded instructions and a touch-screen computer. The battery has demonstrated good construct validity compared to standard neuropsychological measures and has been shown to have good test-retest reliability^(19–20). For the current study, tests were categorized into four domains: attention, executive function, memory and language. Specific subtests were as follows:

Attention

Digit span forward assesses basic 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 same order of presentation. The number of digits in each sequence is gradually increased from 3 to 9, with two sequences at each level. The score for this task is the total number of correct trials.

Span of visual memory⁽²¹⁾—Participants are asked to re-create highlighted forward and backward patterns on the screen. Total number of correct trials is measured.

Switching of Attention-Digits—This test is a computerized adaptation of the Trail Making Test A⁽²²⁾. 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 and time to completion is used as measurement of performance.

Executive function

Switching of attention—digits and letters—This test is a computerized adaptation of the Trail Making Test B⁽²²⁾. 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. Total time to completion is used as a measure.

Maze task—The maze task assesses executive function and is a computerized adaptation of the Austin Maze⁽²³⁾. 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. The task ends when participants have completed the maze twice without error, or after 10 minutes has passed. Total number of errors and the total number of overruns committed are measured.

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 target words (i.e., words from the original list). After a 20-minute delay, participants are again asked to recall target words. Finally, a recognition trial comprised of target words and foils is completed. From this test four variables are generated and include; total learning (number of words recalled on learning trials), short-delay free recall, long-delay free recall, and recognition.

Language

Verbal fluencies—This test has two components; letter fluency and animal 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. For the animal fluency task, participants are asked to generate as many animal names as they can in 60 seconds. The letter fluency score is based on the number of words produced across three trials whereas the animal fluency score is the total number of correct animal names.

Statistical Analyses

Cognitive impairment on the MMSE was first determined using published cutoff scores (<24)⁽²⁴⁾. However, because bariatric surgery candidates often demonstrate more mild cognitive impairment, additional analyses were conducted using the more liberal cutoff scores of 27, and 28^(15–16). For the Integneuro test battery, raw scores for each of the tests were transformed into z-scores based on age, gender, and estimated intelligence using standardized approaches for this measures. A composite score for each cognitive domain (memory, attention, executive function, and language) was then created by averaging the z-scores from each of the specific tests within that domain. Impairment in each domain was defined using clinical convention (at least 1.5 SD below the normative mean). Overall cognitive impairment on the Integneuro test battery was defined as clinically meaningful impairment in at least one domain.

The sensitivity and specificity of the MMSE at each cutoff was calculated by comparing detection rates of impairment on the MMSE to the specific tests from the Integneuro test battery. Bivariate correlations were also conducted to examine the relationship between performance in each of the cognitive domains measured by the Integneuro and MMSE.

Results

Cognitive impairment on at least one domain of the Integneuro test battery was found in 48.4% of the sample, with deficits in executive function being most common (40%). Approximately 20% of patients were impaired in attention and 16.7% impairment was found in memory and language domains.

MMSE scores ranged from 22 to 30 with the average score being 27.80 ($SD = 2.48$). When impairment on the MMSE was defined using the published cutoff of 24, only 6.5% of individuals were considered impaired. Using cutoffs of 27 and 28 resulted in 29.0 and 41.9 percent of the sample being identified as impaired, respectively.

The overall correct classification rate (i.e., the percent of individuals identified as impaired or not on the MMSE compared to exhibiting impairment in any domain of cognitive

function on the Integneuro) was 48.1% for a cutoff of 24, 54.8% for a cutoff of 27, and 61.3% for a cutoff of 28. Not surprisingly, a cutoff of 24 on the MMSE was not sensitive to impairment on the Integneuro battery (sensitivity ranging from 0-.24 across domains) but was highly specific (specificity ranging from .92 to 1 across domains). A cutoff of 28 yielded the highest overall classification rate (61.3%) with the highest sensitivity (ranging from .50 to .80 across domain) to impairment. A cutoff of 27 yielded slightly better specificity for detecting impairment than a cutoff of 28. Full results are presented in Table 1.

Total MMSE scores did not correlate with the composite scores of any domain of cognitive function from the Integneuro (r 's ranged from .003 to $-.230$, p 's $> .20$). Bivariate correlations revealed that raw MMSE scores were only significantly correlated with the dichotomous memory impairment variable ($r = -.44$, $p = .02$).

Discussion

Consistent with previous work, results of this study demonstrate that cognitive impairment is common among bariatric surgery candidates⁽¹⁻³⁾ with nearly half of patients demonstrating impairment in at least one cognitive domain. Detection of cognitive impairment is particularly important in severely obese persons, as research has demonstrated that cognitive dysfunction is an independent predictor of post-operative weight loss outcomes⁽¹⁾. Unfortunately, the current findings demonstrate that one of the most commonly used cognitive screeners, the MMSE, is not sensitive to cognitive impairment in this population, even when using more liberal cutoffs (i.e. cutoff scores of 27 and 28). These findings are perhaps not surprising given that the MMSE was originally developed as a tool for detecting Alzheimer's disease, which is characterized by primary deficits in memory. In contrast, obese individuals often demonstrate impairment in executive function which may not be captured by the MMSE.

The identification of cognitive impairment, particularly executive dysfunction, is important in this population as it may limit a patient's ability to adhere to necessary lifestyle changes. Executive function refers to higher order cognitive abilities and includes inhibition, organization, planning, and cognitive flexibility.⁽²⁵⁾ In bariatric surgery patients, deficits in these abilities could lead to difficulties adhering to post-operative guidelines. For example, executive dysfunction may make it more difficult for a patient to plan and follow through with preparing healthy meals, tracking calorie intake, and scheduling time for physical activity. Additionally, memory deficits may make it more difficult for a patient to recall recommendations and post-operative guidelines. Consistent with this notion, we recently identified an association between reduced cognitive function and self-reported adherence among bariatric surgery patients.⁽⁵⁾ Thus, increasing patient adherence among patients with cognitive impairment may be an important target for clinicians. One way this may be accomplished is through closer monitoring of patients who are identified as being at-risk for reduced outcomes due to cognitive impairment, perhaps through more frequent contact with care providers.

Additionally, these patients may benefit from interventions targeted for their areas of weakness. Although research is needed to examine their efficacy in the bariatric surgery

population, behavioral interventions aimed at improving organizational skills, time management and planning have been shown to improve daily functioning in children with ADHD.^(26, 27) It is possible that these types of programs, adapted for use in bariatric surgery patients, may be beneficial. Such interventions might focus on increasing self-monitoring and organizational skills to help them create and stick to specific and structured plans for physical activity and diet. These interventions might be achieved through the use of internet-based technology (e.g., smartphone apps) which can be easily tailored for the needs of the individual and may be more feasible and easily accessible than increased visits to the doctor's office.⁽²⁸⁾ Smartphone-based technology has already been shown to be helpful in assisting individuals with memory impairment improve daily functioning^(29, 30)

Such findings argue for the importance of screening for cognitive impairment in bariatric surgery candidates. However, a recent study found that bariatric surgery patients are unable to accurately report their level of cognitive impairment⁽³¹⁾, highlighting the need for objective measures to detect impairment. The current results extend this pattern and suggest that the MMSE may not be sensitive to the cognitive impairment found in bariatric surgery patients, similar to some other medical populations.^(32, 33) Future research should examine the utility of other screeners in this population. For example, the Montreal Cognitive Assessment (MoCA)⁽³⁴⁾ has been shown to be useful in detecting mild cognitive impairment⁽³⁴⁾ in medical samples such as individuals with cerebrovascular disease⁽³⁵⁾, stroke⁽³⁶⁾ and heart failure⁽³⁷⁾. Unfortunately, the average age of bariatric surgery candidates is around 39⁽³⁸⁾ and many of the existing cognitive screeners were developed for use in older individuals. It is possible that a different approach to screening may be needed in this population and research is needed to examine this possibility, including the possible need to develop a new screening measure.

The results of this study must be viewed in light of several limitations. First, the modest sample size limits the generalizability of these results, particularly because of the small number of older adults in the study. It is possible that the MMSE may be more useful in detecting cognitive impairment among older bariatric surgery patients, though there was little correlation between the MMSE and age in the current sample ($r = -.285$, $p = .121$). Additionally, the sample was composed of relatively cognitively intact individuals (i.e. excluded for neurological and severe psychiatric disorders) resulting in a sample that may not be entirely representative of all patients who present for surgery. Additionally, although the current study employed a comprehensive neuropsychological test battery known to be sensitive to cognitive impairment in obese persons, it is not a substitute for a full neuropsychological evaluation that includes detailed interview, medical record review, and comprehensive testing⁽²⁵⁾. It is possible that a formal evaluation may produce differential impairment rates and future research should clarify this possibility.

Conclusions

In brief summary, cognitive impairment is common among bariatric surgery candidates and detection of impairment has important implications for post-operative outcomes. This study found that the MMSE was not useful as a screener for cognitive impairment in this sample, highlighting the need for the examination of the utility of existing cognitive screeners or the

development of new ways to detect cognitive impairment among bariatric surgery patients prior to surgery.

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Table 1

Sensitivity (Specificity) of the MMSE in Detecting Impairment with Varying Cutoff Scores (N = 30)

Cutoff Scores	24	27	28
Overall Impairment	.13(1.0)	.33(.75)	.53(.69)
Memory	.20(.96)	.80(.80)	.80 (.65)
Attention	.00(.92)	.50(.75)	.67 (.64)
Executive Function	.17(1.0)	.33(.72)	.50 (.63)
Language	.00(.92)	.20 (.68)	.60 (.62)

MMSE - Mini-Mental State Examination