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Effects of Body Mass Index and Education on Verbal and NonVerbal Memory

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Abstract

We previously reported that higher education protects against executive dysfunction related to higher body mass index (BMI) in younger, but not older, adults. We now extend the previous analyses to verbal and nonverbal memory. Fifty-nine healthy, dementia-free community-dwelling adults ranging in age from 18 to 81 years completed the Hopkins Verbal Learning Test-Revised and the Brief Visuospatial Memory Test-Revised. Self-reported years of education served as a proxy for cognitive reserve. We found that more highly educated individuals maintained their immediate recall performance across the range of BMI, but in less educated individuals, higher BMI was associated with worse performance. Our findings suggest that education may play a protective role against BMI-related nonverbal learning deficits, similar to previous reports for verbal memory and executive functioning. Results highlight the importance of considering educational background when determining the risk for BMI-related cognitive impairment in clinical settings.

Keywords

BMI; cognitive reserve; learning; obesity; cognitive deficit

Introduction

Obesity, often measured by body mass index (BMI), is an epidemic and a major health problem in the United States. Approximately 33% of 20- to 39-year-olds, 37% of 40- to 59-year-olds and 35% of older adults are obese (Ogden, Carroll, Kit, & Flegal, 2012). In addition to its association with various vascular conditions (Kopelman, 2000), obesity is also associated with dementia (Elias, Goodell, & Waldstein, 2012; Gustafson, Rothenberg, Blennow, Steen, & Skoog, 2003; Ho et al., 2010) and impairment in cognitive functions,

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particularly executive functioning (Fagundo et al., 2012; Gunstad et al., 2007; Kirton & Dotson, 2015). This relationship may be due, at least in part, to obesity-related brain changes, including cerebral atrophy and white matter lesions (D. Gustafson, Lissner, Bengtsson, & Björkelund, 2004; D. R. Gustafson, Steen, & Skoog, 2004). We recently reported that the association between BMI and executive dysfunction is moderated by cognitive reserve (Kirton & Dotson, 2015), which is thought to reflect the ability to optimize performance in the face of brain pathology through differential recruitment of brain networks (Steffener & Stern, 2012; Stern, 2002). Specifically, we found that education—a common proxy for cognitive reserve (Springer, McIntosh, Winocur, & Grady, 2005; Valenzuela, 2008)—protected against BMI-related executive dysfunction, consistent with previous studies demonstrating that individuals with high cognitive reserve have preserved cognitive functioning or less cognitive decline related to various diseases (Chillemi et al., 2015; McLaren, Szymkowicz, Kirton, & Dotson, 2015; Nunnari, Bramanti, & Marino, 2014).

The goal of the present study was to expand upon our previous findings by determining whether or not education moderates the relationship between BMI and memory functioning. BMI-related impairments in both verbal (Benito-León, Mitchell, Hernández-Gallego, & Bermejo-Pareja, 2013; Cournot et al., 2006) and nonverbal (Boeka & Lokken, 2008) memory have been reported; however, these results are not consistent across studies (Gonzales et al., 2010; Stanek et al., 2013; Waldstein & Katzel, 2006). At least one study demonstrated a protective effect of cognitive reserve on verbal memory (Galioto, Alosco, Spitznagel, Stanek, & Gunstad, 2013), but whether or not a similar relationship exists for nonverbal memory is unclear. We predicted that lower educational attainment and higher BMI would be associated with worse memory performance. Additionally, we predicted that education would moderate the effect of BMI on verbal and nonverbal memory, such that a higher level of education would serve as a protective factor against memory deficits in overweight and obese individuals.

Methods

Participants

Participants were recruited from the University of Florida and surrounding community. Participants were included if they were native English speakers, with no less than nine years of education. This study is part of a larger study that included magnetic resonance imaging (MRI; data not reported here); therefore, we excluded participants with MRI contraindications and only included right-handed individuals. Additional exclusionary criteria included self-reported neurological and major medical conditions, head injury, learning disorders, language comprehension difficulties, and scores less than 30 on the Telephone Interview for Cognitive Status (TICS; Brandt, Spencer, & Folstein, 1988), the suggested cut-off for dementia. The final sample included 59 individuals, with age ranging from 18–81 years and education ranging from 10–20 years. Characteristics of the study sample are presented in Table 1. The study protocol was approved by the University of Florida Health Science Center Institutional Review Board. All participants gave both written and verbal informed consent to participate in the study.

Memory Measures

The Hopkins Verbal Learning Test – Revised (HVLT-R; Benedict, Schretlen, Groninger, & Brandt, 1998) is a verbal learning and memory test that consists of a list of 12 words that participants are required to learn across three trials. The Total Recall score was calculated by summing the number of correctly recalled items across these three learning trials. The Delayed Recall score was calculated by totaling the number of words participants could freely recall 20–25 minutes after the end of the third learning trial.

The Brief Visuospatial Memory Test – Revised (BVM-T-R; Benedict, Schretlen, Groninger, Dobraski, & Shpritz, 1996) is a visual learning and memory test in which an array of 6 simple figures is presented for 10 seconds during 3 learning trials, after which participants are asked to replicate the array. Credit is given for accuracy of the drawing, as well as placement of the figure within the array. The Total Recall score was calculated by summing these scores across the three learning trials, while the Delayed Recall score was calculated by summing the scores on a free recall trial conducted 25 minutes after the end of the third learning trial.

Body Mass Index (BMI)

BMI was calculated from self-reported height (in feet and inches) and weight (in pounds) using the National Heart Lung and Blood Institute website calculator (WHO Expert Consultation, 2004). The WHO defines healthy weight as a BMI ranging from 18.5 to 24.9, overweight as a BMI ranging from 25 to 29.9, and obesity as a BMI ≥ 30 . Each participant was categorized into either a healthy weight, overweight or obese BMI group based on this criterion.

Cognitive Reserve

Education served as a proxy for cognitive reserve. The number of years of education was based on self-report.

Covariates

Vascular risk score—A vascular risk score was calculated for each participant. Participants self-reported medical diagnoses and medications. One point was given for each reported diagnosis and/or medication for diabetes mellitus type 2, hypertension, or hypercholesterolemia. This yielded a vascular risk score ranging from 0 to 3, with higher scores indicating greater vascular risk. This score was used as a covariate in statistical analyses.

Depressive symptoms—The 20-item Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977) was used to assess the presence and severity of current depressive symptoms. The CES-D is a widely used self-report measure of depressive symptoms that has been validated in older adults (Haringsma, Engels, Beekman, & Spinhoven, 2004). Total scores on this measure range from 0 to 60.

Anxiety symptoms—The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a widely used measure of anxiety that includes state and

trait subscales, which measure situational (i.e., at the time of testing) and dispositional symptoms of anxiety, respectively. The current study used only the Trait subscale, which ranges in score from 20–80, with higher scores indicating greater dispositional anxiety.

Statistical Analyses

IBM SPSS Statistics version 21 (Armonk, 2007) was used for all statistical analyses. Mixed general linear model analyses were conducted to explore the main effects and the interaction effect of BMI (categorical variable with healthy, overweight and obese groups) and years of education (continuous variable) on the total recall and delayed recall scores on the HVLT-R and BVMT-R. Separate models were conducted for each cognitive test. Age, sex, vascular risk scores, CES-D scores, and STAI Trait scores were initially entered in the models as covariates; however, all variables except age were removed from the final models due to lack of statistical significance. Statistical significance was set at $\alpha = 0.05$.

Results

As expected, higher education was associated with better performance on BVMT-R Total Recall, $F(1, 58) = 7.18956, p = 0.010, \eta_p^2 = 0.121$, and Delayed Recall, $F(1, 58) = 4.666, p = 0.035, \eta_p^2 = 0.082$. Additionally, we found a significant main effect of BMI on BVMT-R Total Recall, $F(2, 57) = 3.319, p = 0.044, \eta_p^2 = 0.113$, with highest scores for healthy weight individuals and lowest scores for overweight individuals. The interaction between years of education and BMI was also significant for BVMT-R Total Recall, $F(2, 57) = 3.496, p = 0.038, \eta_p^2 = 0.119$, such that being overweight and obese was associated with lower scores in less highly educated individuals, but not in those with higher levels of education (Figure 1).

The interaction between BMI and education was not significant for BVMT-R Delayed Recall. No significant effects were found for BMI, years of education, and their interaction on HVLT-R performance.

Discussion

The goal of this study was to expand upon our previous finding that education protected against obesity-related executive dysfunction (Kirtan & Dotson, 2015) by examining whether or not education moderates the relationship between BMI and memory functioning. Consistent with our hypothesis, we found that higher BMI was associated with worse nonverbal learning in individuals with lower education, but those with higher education performed similarly across BMI groups. Contrary to expectation and to a recent study (Galioto et al., 2013), we did not find a moderating effect of cognitive reserve, as measured by education, on verbal memory.

Neuroimaging studies suggest that cognitive reserve impacts activation patterns (Habeck et al., 2003) and functional connectivity (Panda et al., 2014) during nonverbal memory tasks. Together with evidence that higher body weight impacts functional brain activity (Hsu et al., 2015; Kullmann et al., 2012), this indirectly suggests that greater efficiency of brain networks in more highly educated individuals might explain the present results. The reasons

why education did not similarly moderate the association of BMI with verbal memory is less clear, particularly given significant findings in a recent study that examined a sample that is demographically similar to the sample in the current study (Galioto et al., 2013). Of note, we did not observe the expected main effects of education and BMI on verbal memory. Given the high performance on both immediate and delayed recall in our sample, it is possible that a ceiling effect on the HVLt-R limited the ability to detect moderating variables. The discrepancy may also be explained in part by the different proxy measures of cognitive reserve between the present study, which used education, and the study by Galioto and colleagues (2013), which used premorbid intelligence estimated by a word reading task. Although both are accepted proxies of cognitive reserve and they are highly correlated (Jones et al., 2011), the verbal nature of the word reading task may be more closely related to verbal memory performance.

Current findings should be considered within the context of study limitations, including the relatively small sample size, ethnic homogeneity of the sample, and lack of information about potentially confounding variables, included socioeconomic status and physical activity level. The uneven distribution of BMI groups can also be seen as a limitation. To control for bias due to the uneven distribution in groups, follow-up analyses were conducted in which the overweight and obese group were combined, yielding an elevated BMI group of 47.5% and a healthy weight group of 52.5%. These analyses yielded similar results as the previously described ones, suggesting that an uneven distribution did not influence the results.

Overall, our findings highlight the importance of maintaining a healthy body weight to reduce the risk of nonverbal memory deficits. Additional research is needed to further clarify moderating variables that may protect against obesity-related cognitive dysfunction. This line of work has important implications for clinical neuropsychologists, as it may assist in determining the risk for BMI-related cognitive impairment in individuals from various educational backgrounds.

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Figure 1.

The interaction between education and BMI on the Total Recall scores of the Brief Visuospatial Memory Test – Revised

Table 1

Demographic characteristics

	Mean/N (%)	SD	Range
Age (years)	42.78	22.82	18–81
Gender (% female)	38 (64.4%)	--	--
Education (years)	15.01	2.56	10–20
BMI Group			
Healthy Weight	31 (52.5%)	--	--
Overweight	17 (28.8%)	--	--
Obese	11 (18.6%)	--	--
HVLT-R Total Recall	27.07	4.30	16–35
HVLT-R Delayed Recall	9.53	2.05	4–12
BVMT-R Total Recall	27.49	5.70	12–35
BVMT-R Delayed Recall	10.61	1.77	5–12

Note BMI = Body Mass Index; HVLT-R = Hopkins Verbal Learning Test – Revised BVMT-R = Brief Visuospatial Memory Test – Revised.