Examining the Influence of Measures of Adiposity on Cognitive Function in Middle Age and Older African Americans

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Abstract

The objectives of the study were to examine whether measures of total obesity (body mass index [BMI]) and central obesity (waist circumference [WC] and waist-to-hip ratio [WHR]) are associated with cognitive function in African Americans, and whether sex moderates these associations. A sample of 194 African Americans, with a mean age of 58.97 years, completed a battery of cognitive tests and a self-reported health questionnaire. Height, weight, waist and hip circumference, and blood pressure were assessed. Linear regression analyses were run. Results suggested lower performance on measures of verbal fluency and complex attention/cognitive flexibility was accounted for by higher levels of central adiposity. Among men, higher WHR was more strongly related to complex attention/cognitive flexibility performance, but for women, WC was a salient predictor. Higher BMI was associated with poorer verbal memory performance among men, but poorer nonverbal memory performance among women. Findings suggest a need for healthy lifestyle interventions for African Americans to maintain healthy weight and cognitive function.

Keywords: African Americans; Learning Obesity; Cognitive function and memory

Introduction

Optimal cognitive function is a strong predictor of quality of life as we age (Hollenberg, Testa, & Williams, 1991). Overweight status and obesity have been associated with decrements in cognitive function, independently of other cardiovascular risk factors (Elias, Elias, Sullivan, Wolf, & D’Agostino, 2003; Elias, Goodell, & Waldstein, 2012). For example, body mass index (BMI), a measure of total obesity, has been linked to poorer performance on cognitive tests (Cournot et al., 2006). Likewise, waist circumference (WC) and waist-to-hip ratio (WHR), measures of central obesity, have been associated with poorer cognitive performance, and are more strongly related to cognitive decrements than total obesity (Elias et al., 2012). The associations between weight and cognitive function are a major health concern, as overweight status and obesity are associated with the development of dementia, a growing healthcare epidemic (Stewart et al., 2005).

Several biological mechanisms help to explain the link between obesity and cognitive decrements. These pathways include reduced cerebral blood flow, increased atherosclerosis in the carotid and large cerebral arteries, white matter disease, silent brain infarction, and brain atrophy (Koga et al., 2002; Price et al., 1997). Metabolic dysfunction, as demonstrated by impaired central nervous system glucose signaling and disruption of neurotransmitter expression, has also been implicated as a pathological mediator linking obesity and cognitive function (Blasco et al., 2014).

African Americans have an increased risk for cognitive decline, stroke, and dementia. High rates of obesity may partially explain the disproportionately higher rates of cognitive decline, stroke, and dementia among African Americans, when compared with other racial/ethnic groups (Froehlich, Bogardus, & Inouye, 2001; Tang et al., 2001). Seventy percent of

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African-American men and nearly 82% of African-American women are classified as overweight or obese (Flegal, Carroll, Kit, & Ogden, 2012). Given the higher rate of overweight and obesity in this population, the current study sought to primarily examine whether BMI, WHR, and WC were associated with decrements in cognitive function within this population, independently of other health contributors. In addition, because African-American women are more likely to be overweight or obese than African-American men (Flegal et al., 2012), we examined whether associations varied by sex.

Method

Participants

Participants were African Americans who were part of a larger study conducted by the Health Promotion and Risk Reduction Research Center (HealthPARC) entitled, the “Study of Cognitive Aging” (SOCA). The primary purpose of SOCA was to explore relations among cardiovascular disease (CVD) risk factors and cognitive function in middle and old age. Participants were recruited from the Washington, DC metropolitan area through advertisement at Howard University, Howard University Hospital, non-assisted senior living facilities, and senior centers. Exclusion criteria included age <40 years, self-reported history of dementia, traumatic brain injury, or recent stroke, and suspected dementia (Telephone Interview of Cognitive Status score <21; Cook, Marsiske, & McCoy, 2009). The Howard University Institutional Review Board approved the study. Participants were compensated $60 for completion of study requirements.

Obesity Measures

Weight in kilograms and height in centimeters were used to calculate BMI. WC was measured at the level of the umbilicus. WC is often used as a measure of central adiposity and is arguably a better predictor of CVD risk than total obesity (Gelber et al., 2008). Hip circumference was measured at the widest part of the hip. WHR was calculated from WC and hip circumference, as a measure of central adiposity, and has been suggested as a stronger predictor of mortality than total obesity (Price, Uauy, Breeze, Bulpitt, & Fletcher, 2006).

Cognitive Measures

Verbal fluency, Inhibition, Complex attention, cognitive flexibility, and psychomotor speed, verbal memory, and nonverbal memory are intended to be a subheading level below Cognitive Measures. Each test should be an additional level below those five subheadings. I’m not sure how these should appear—italicized or otherwise—as the ACN article examples I’ve looked at do not follow APA heading level rules.

Verbal fluency

**Verbal Fluency Test.** The Delis–Kaplan Executive Function System (DKEFS) Verbal Fluency Test measures verbal fluency, a component of executive function, and generates letter fluency, category fluency, and category switching scores (Delis, Kaplan, & Kramer, 2001).

Inhibition

**Stroop Color Word Test.** The Stroop Color Word Test assesses inhibition, the ability to suppress the urge to perform a primary response in order to attend to a response that is secondary. The Stroop interference score reflects degree of inhibition and was calculated using the Golden method for use in the analyses (Golden, 2002).

Complex attention, cognitive flexibility, and psychomotor speed

**The Trail Making Test.** The Trail Making Test (TMT) is administered in two parts that are timed: A and B. Both tests require complex attention and psychomotor speed, but TMT B also requires cognitive flexibility (Reitan, 1992). Scores reflect time taken to complete the tasks; thus, higher scores reflect poorer performance.

Verbal memory

**Rey Auditory Verbal Learning Test.** The Auditory Verbal Learning Test (AVLT) measures short-term verbal memory, rate of verbal learning, and verbal learning strategies (Rey, 1941). Subjects are provided a list of 15 semantically unrelated words that are repeated over five trials and are asked to recall the words. The total free recall score was used in the current analysis.
Nonverbal memory

**Benton Visual Retention Test.** The Benton Visual Retention Test assesses visual memory, visual perception, and visuoconstructional abilities (Benton, 1992). Subjects examine 10 designs and reproduce each from memory as exactly as possible.

**Alpha Span Task.** The Alpha Span Task measures working memory and the ability to recall words during manipulation (Craik, 1986). Subjects are required to recall presented words that are stored prior to computing simple mathematical problems.

**Covariates**

Covariates were selected based on the relevant literature then confirmed based on significant relations to BMI, WC, WHR and/or cognitive outcomes. Age and formal years of education attained were obtained by self-report. Seated blood pressure was taken on three separate occasions: prior to cognitive assessment, immediately following assessment, and following psychosocial assessment. The average of the three measures was used. Type 2 diabetes status and physical activity (days per week) were self-reported. The Center for Epidemiologic Studies-Depression (CES-D) Scale was included as a measure of depressive symptomatology (Radloff, 1977). Variables that were tested as potential covariates, but unrelated to predictor or outcome variables, included diastolic blood pressure, pulse pressure, mean arterial pressure, smoking status, self-reported high cholesterol, and number of alcoholic drinks per week.

**Statistical Analyses**

The Statistical Package for the Social Sciences (SPSS) 23.0 and the PROCESS macro for SPSS (Hayes, 2013) were used for all analyses. Descriptive statistics were computed for all predictor variables (i.e., sex and BMI, WHR, and WC), outcome variables (i.e., cognitive scores), and covariates. Multiple linear regression was used to assess associations between measures of obesity and obesity × sex interaction terms, adjusting for the aforementioned covariates. Given the high correlations among BMI, WHR, and WC, each predictor was examined in separate analyses. TMT A and TMT B were log transformed to correct positive skewness and significant kurtosis.

**Results**

**Descriptive Statistics**

A total of 198 participants completed the study. Four participants with standardized residuals of approximately |3.3| or greater on TMT A or TMTB were identified as outliers in the regression solutions and were deleted for a final sample size of 194. Sample characteristics and cognitive scores are presented in Table 1. The mean age was 58.97 years (SD = 10.60), mean educational attainment 13.64 years (SD = 3.06), and more than half of the subjects were women (54%). Mean BMI was 30.24 kg/m^2 (SD = 6.80). In total, 24.86% of the sample was normal weight (BMI < 25 kg/m^2), 26.49% overweight (BMI ≥ 25 and <30 kg/m^2), 25.95% obese (BMI ≥ 30 and <35 kg/m^2), 11.89% severely obese (BMI ≥ 35 and <40 kg/m^2), and 10.81% morbidly obese (BMI ≥ 40 kg/m^2). Mean WC was 104.49 cm (SD = 15.76) for men and 99.20 cm (SD = 14.39) for women, which is considered abnormally obese. Mean WHR was 0.95 (SD = 0.07) for men and 0.87 (SD = 0.09) for women, which is also considered abnormally obese. Approximately 20% of subjects self-reported a diagnosis of diabetes and 49% self-reported alcohol use.

Table 2 illustrates the results of the linear regression analysis. Higher WC was associated with poorer category switching performance after adjusting for age, education, systolic blood pressure, Type 2 diabetes, physical activity, and depressive symptomatology (B = −0.10, p < .05). Likewise, BMI was significantly and inversely associated with Letter Fluency performance (B = −0.59, p < .05). None of the measures of obesity had a direct association with measures of inhibition, nor were there significant interactions. Significant findings emerged for complex attention and cognitive flexibility. A significant, inverse association between WC and TMT B emerged (B = −2.24, p < .05), in addition to a significant WC × sex interaction (B = 1.47, p < .05). A plot of this interaction suggested that among women, higher WC was associated with more time to complete the task, whereas men with a higher WC tended to complete the task more quickly (see Supplementary material online, Fig. S1a).

Similarly, a significant WHR × sex interaction was found (B = 267.93, p < .05). Here, the plot suggested that higher WHR was associated with more time to complete TMT B among men, but the illustrated association was relatively flat among women (see Supplementary material online, Fig. S1b). Lastly, a significant WHR × sex interaction was found for TMT A. Again the plot suggested that higher WHR was associated with more time to complete TMT A among men, but the association was relatively flat among women (see Supplementary material online, Fig. S1c). BMI was inversely associated with verbal memory as measured by the AVLT (B = −0.48, p < .01). BMI × sex also had a significant association with AVLT (B = 0.31,
### Table 1. Descriptive statistics for participant characteristics and cognitive test scores

|                                | Total sample | Men | Women | Number of Participants | Mean | SD | Mean | SD | Mean | SD |
|--------------------------------|--------------|-----|-------|-------------------------|------|----|------|----|------|----|
| **Gender**                     |              |     |       |                         |      |    |      |    |      |    |
| **Age of participants (years)**|              |     |       |                         | 58.97| 10.60| 58.89| 9.84| 59.04| 11.24|
| **Education (years)**          |              |     |       |                         | 13.64| 3.06| 13.49| 2.67| 13.77| 3.36|
| **Self-reported DM (%)**       |              |     |       |                         | 19.6%|      | 21.3%|      | 18.9%|      |
| **Drinks per week**            |              |     |       |                         | 1.79 | 3.85| 2.19 | 3.65| 1.45 | 96 |
| **Average SBP (mmHg)**         |              |     |       |                         | 132.61| 19.21| 134.42| 20.13| 131.07| 12.42|
| **Average DBP (mmHg)**         |              |     |       |                         | 80.80| 14.00| 81.77| 15.68| 79.98| 6.96|
| **CES-D total score**          |              |     |       |                         | 12.96| 10.40| 12.01| 9.11| 13.73| 11.34|
| **BMI (kg/m²)**                |              |     |       |                         | 30.24| 6.80| 29.21| 6.96| 31.11| 6.57|
| **WC (cm)**                    |              |     |       |                         | 101.61| 15.22| 104.49| 15.76| 99.19| 14.39|
| **WHR**                        |              |     |       |                         | 0.90 | 0.09| 0.95 | 0.07| 0.87 | 0.09|
| **Verbal fluency**             |              |     |       |                         |      |     |      |    |      |    |
| Category fluency               |              |     |       |                         | 36.98| 8.80| 35.69| 8.08| 38.05| 9.25|
| Category switching             |              |     |       |                         | 12.78| 3.34| 12.13| 2.90| 13.33| 3.59|
| Letter fluency                 |              |     |       |                         | 35.88| 13.61| 34.19| 12.63| 37.25| 14.27|
| **Inhibition**                 |              |     |       |                         |      |     |      |    |      |    |
| Stroop interference            |              |     |       |                         | -4.15| 8.66| -3.35| 9.09| -4.87| 8.24|
| Stroop Color Word              |              |     |       |                         | 34.39| 7.48| 33.78| 7.80| 34.95| 7.18|
| **Complex attention, cognitive flexibility, psychomotor speed/scanning** | | | | | | | | | | |
| TMT A                          |              |     |       |                         | 1.65 | 0.19| 1.66 | 0.20| 1.65 | 0.20|
| TMT B                          |              |     |       |                         | 2.03 | 0.22| 2.05 | 0.20| 2.02 | 0.23|
| **Verbal memory**              |              |     |       |                         |      |     |      |    |      |    |
| AVLT                           |              |     |       |                         | 4.42 | 2.08| 4.36 | 2.18| 4.48 | 1.99|
| **Nonverbal memory**           |              |     |       |                         |      |     |      |    |      |    |
| BVRT                           |              |     |       |                         | 5.12 | 1.62| 5.15 | 1.66| 5.10 | 1.58|

**Note:** DM = diabetes mellitus; SBP = systolic blood pressure; DBP = diastolic blood pressure; CES-D = Center for Epidemiological Studies-Depression Scale; BMI = body mass index; WC = waist circumference; WHR = waist-to-hip ratio; TMT A = Trail Making A; TMT B = Trail Making B; AVLT = Auditory Verbal Learning Test; BVRT = Benton Visual Retention Test.

### Table 2. Unstandardized coefficients and standard error values reflecting cognitive test scores regressed on measures of obesity after adjustment for age, education, systolic blood pressure, Type 2 diabetes status, physical activity, and depressive symptomatology

|                      | BMI       | BMI × sex | WHR       | WHR × sex | WC       | WC × sex |
|----------------------|-----------|-----------|-----------|-----------|----------|----------|
|                      | B | SE | B | SE | B | SE | B | SE | B | SE |
| Verbal fluency       | 0.03 | 0.07 | -0.01 | 0.04 | -1.81 | 7.10 | 0.29 | 6.08 | -0.10 | 0.05 | 0.05 | 0.03 |
| Category switching   | -0.25 | 0.18 | 0.16 | 0.10 | 15.76 | 17.85 | -19.86 | 15.33 | -0.12 | 0.13 | 0.09 | 0.08 |
| Category fluency     | -0.59 | 0.28 | 0.32 | 0.17 | -13.41 | 28.81 | 7.12 | 24.74 | -0.003 | 0.20 | 0.01 | 0.12 |
| Letter fluency       | -0.85 | 0.19 | -0.02 | 0.11 | -14.59 | 18.05 | 5.40 | 15.45 | 0.02 | 0.13 | 0.004 | 0.08 |
| Inhibition            | 0.08 | 0.22 | 0.05 | 0.13 | 10.23 | 20.93 | -24.11 | 17.91 | -0.01 | 0.15 | -0.03 | 0.09 |
| Stroop interference  | -0.11 | -0.11 | 0.05 | 0.13 | 14.59 | 18.05 | 5.40 | 15.45 | 0.02 | 0.13 | 0.004 | 0.08 |
| Stroop Color Word    | -0.01 | 0.01 | -0.02 | 0.11 | -14.59 | 18.05 | 5.40 | 15.45 | 0.02 | 0.13 | 0.004 | 0.08 |
| Complex attention, cognitive flexibility | | | | | | | | | | | |
| TMT A                | 0.16 | 0.48 | -0.05 | 0.28 | -72.82 | 45.33 | 91.46 | 39.43 | -0.02 | 0.32 | 0.19 | 0.20 |
| TMT B                | -2.53 | 1.62 | 1.45 | 0.95 | -32.14 | 155.87 | 267.93 | 135.58 | -2.24 | 1.11 | 1.47 | 0.67 |
| Verbal memory        | -0.48 | 0.19 | 0.31 | 0.01 | -13.22 | 19.82 | 7.78 | 16.99 | -0.13 | 0.14 | 0.07 | 0.08 |
| Nonverbal memory     | -0.04 | 0.04 | 0.004 | 0.02 | 0.46 | 4.41 | -1.11 | 3.90 | 0.002 | 0.03 | -0.01 | 0.02 |
| Alpha Span           | 0.07 | 0.03 | -0.04 | 0.02 | -3.24 | 3.07 | 2.94 | 2.67 | 0.01 | 0.02 | -0.01 | 0.01 |

**Notes:** BMI = body mass index; WHR = waist-to-hip ratio; WC = waist circumference; TMT A = Trail Making A; TMT B = Trail Making B; AVLT = Auditory Verbal Learning Test; BVRT = Benton Visual Retention Test.

*p < .05.

**p < .01.
The plot of the interaction showed that for women, higher BMI was associated with poorer AVLT performance, but for men, higher BMI was associated with higher performance (see Supplementary material online, Fig. S1d). Finally, when nonverbal memory was analyzed, BMI was positively associated with Alpha Span ($B = 0.07, p < .05$) and there was a significant BMI $\times$ sex interaction ($B = -0.04, p < .05$). A plot of the interaction showed that higher BMI was associated with poorer Alpha Span performance for men but better performance for women (see Supplementary material online, Fig. S1e).

Discussion

Our results showed that measures of central obesity are significantly associated with cognitive function (verbal fluency and complex attention/cognitive flexibility), independently of other factors known to compromise cognitive function. For complex attention/cognitive flexibility tasks, higher WHR tended to be more detrimental for men, but WC was more detrimental for women. Total obesity also showed a significant association with certain cognitive domains—verbal and nonverbal memory. For women, higher BMI tended to be more problematic for their verbal memory performance, but for men, it was more problematic for their nonverbal memory performance.

Our findings are consistent with several studies that identify adiposity as an independent risk factor for decrements in cognitive function (Elias et al., 2003, 2012; Waldstein & Katzel, 2006), and extends those findings to African Americans. We expected to find stronger central adiposity-related decrements in cognitive function than total obesity-related decrements; however, total obesity was an important factor. The inconsistent pattern of results for men and women with respect to central adiposity, verbal fluency, and complex attention/cognitive flexibility (examples of executive function) are counter to findings from the Framingham study that noted independent and cumulative negative relations of obesity and hypertension to measures of certain domains of executive function in men, but not in women (Elias et al., 2003). Despite the men in our study being more prone to central adiposity than women, findings for men were no more significant than for women. Similarly, although women had higher BMIs than men, differences in the influence of BMI on cognitive performance showed no sex-related trend. Prior work examining cross-sectional relations between measures of adiposity and memory have yielded mixed results. For example, greater WC and WHR have been associated with poorer visual memory (Gunstad et al., 2007); however, BMI was not associated with episodic learning or memory in a separate study (Ward, Carlsson, Trivedi, Sager, & Johnson, 2005). The current findings suggest that both total and central obesity are potentially harmful for cognitive performance in a number of domains.

Limitations

The cross-sectional design and limited sample size did not permit us to establish temporal relations or generalize broadly. Another limitation of the study was the use of self-reported health data and exclusion of pertinent cardiovascular, metabolic, and biomarker data. The large number of regressions run increased the likelihood of a Type 1 error; however, the pattern of results suggests initial and nonrandom trends for an underrepresented population in the literature. Finally, the absence of a validated physical activity measure was a limitation of the study. Physical activity has been shown to attenuate the relationship between central adiposity and cognitive function (Dore, Elias, Robbins, Budge, & Elias, 2008).

Conclusions

Collectively, these findings suggest that greater adiposity is an independent risk factor for specific cognitive decrements among African Americans. Given our findings, there is a need for targeted interventions that encourage African Americans to adopt healthy lifestyles and maintain a healthy weight to prevent cognitive decrements associated with obesity. African Americans and healthcare providers should pay particular attention to weight located in the abdominal region. Our findings have significant implications for public health, as millions of African Americans are overweight/obese and disproportionately represent those affected by cognitive decline and dementia.

Supplementary Material

Supplementary material is available at Archives of Clinical Neuropsychology online.

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Conflict of Interest

None declared.

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