

Relationships among Blood Pressure, Triglycerides and Verbal Learning in African Americans

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Background: Individuals at greater risk for cardiovascular disease (CVD) display poorer cognitive functioning across various cognitive domains. This finding is particularly prevalent among older adults; however, few studies examine these relationships among younger adults or among African Americans.

Purpose: The objective was to examine the relationships among 2 cardiovascular risk factors, elevated blood pressure and elevated triglycerides, and verbal learning in a community-based sample of African Americans.

Methods: Measurements of blood pressure and triglycerides were obtained in 121 African-American adults and compared to performance on 3 domains of the California Verbal Learning Test-II (CVLT-II).

Results: Blood pressure was not related to CVLT-II performance. Triglyceride levels were inversely related to CVLT-II performance. Higher triglyceride levels were associated with poorer immediate, short delay and long delay recall.

Conclusions: Consistent with studies involving older participants, the current investigation shows that in a nonelderly sample of African Americans, triglyceride levels may be related to cognitive functioning. Because early detection and intervention of vascular-related cognitive impairment may have a salutary effect, future studies should include younger adults to highlight the impact of cardiovascular risk on cognition.

Key words: cognitive functioning ■ African Americans ■ cardiovascular

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Hypertension affects an estimated 65 million people, or about 30% of the adult population in the United States.¹ Among African Americans, the prevalence of hypertension is higher than for other racial groups.² Elevated triglycerides are part of a larger lipid disorder known as dyslipidemia, which affects an estimated 29.3% of Americans age 45–84.³ Among the few studies that have examined the relationship between these cardiovascular risk factors and cognitive functioning within African Americans, a major limitation has been their focus on solely older adult populations.^{4–6} Given that rates of elevated blood pressure and lipid levels are disparate between African Americans and other racial groups beginning as early as young adulthood,² and that elevated blood pressure and elevated lipids are not age-dependent disease states among African Americans, there is a necessity to exam the impact of elevated blood pressure and triglycerides on cognitive functioning across various ages within this racial group, inverse associations that are well documented in the literature on Caucasian Americans.

A number of brain alterations are suspected in the relationship among blood pressure, triglycerides and cognitive functioning. It has been proposed that decreased cognitive functioning associated with hypertension and elevated lipids may be due to enhanced macrovascular disease such as greater carotid atherosclerosis.^{4,7–9} Cerebral blood flow has also been implicated and several studies have noted reduced resting global and regional cerebral blood flow and cerebral metabolic activity in hypertensives as compared to normotensives, as well as smaller cerebral blood flow responses.^{10–12} Additionally, white-matter lesions caused by microvascular disease appear to be associated with cognitive dysfunction.^{10,11,13}

Within studies that examined primarily Caucasian-American participants, blood pressure has been linked to various cognitive processes. There is substantial evidence suggesting that executive functioning,^{14,15} memory,^{4,9,14–16} attention,^{14,16} verbal learning, visual tracking,

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immediate and delayed recall,^{4,17} perceptual speed,^{9,14,15,17} reasoning,^{14,16} and other cognitive domains are impacted by blood pressure.^{4,9,10,13,14,16} The link is found across age groups,^{9,11,12,18,19} contributing to cognitive decline beyond the normal decline that occurs with aging.^{4,5,15,20} In terms of the severity of the cognitive impairment associated with elevated blood pressure, it appears that uncontrolled hypertension results in the worst performance.^{4,21} Studies that have examined African Americans have yielded mixed findings.⁴⁻⁶ A nonsignificant association between blood pressure and mental status in older African Americans was found in a large longitudinal study,⁶ and in a cross-sectional examination of cardiovascular risk factor and cognitive functioning, diastolic blood pressure was not associated with cognitive functioning.⁵ On the contrary, racial differences in blood pressure and cognitive functioning between African Americans and Caucasian Americans were significant within a nonelderly sample. Elevations in blood pressure were associated with poorer cognitive functioning, with stronger inverse associations for African Americans for 4 WAIS test scores (Block Design, Digit Symbol Substitution, Information and Similarities).⁴

The evidence linking triglycerides to cognitive functioning is limited, and the findings are mixed. An inverse relationship between triglyceride levels and performance on various types of cognitive measures has been found among older adults.^{22,23} Conversely, participants given a regimen of a lipid-lowering medication show improved performance on numerous cognitive measures, suggesting that lower triglycerides are associated with greater cognitive performance.^{24,25}

A central component of cognitive functioning is the ability and capacity for memory, learning and access to a knowledge store.²⁶ Memory has been defined as the capacity to retain information and use it for adaptive purposes.²⁷ Learning is the result of memory consolidation and implies effortful activity and careful attention by the learner.²⁴ Learned verbal information is often stored through associations and aided through grouping. The current study examined verbal learning as measured through the learning of word lists. Word list recall tasks are effective for assessing verbal memory and words can be presented in several ways. The strategies that are uti-

lized to aid in retention are important in assessing learning. Across studies, blood pressure and triglycerides have been linked specifically to verbal learning.^{12,14,16,23} This relationship is not muted by age effects, as verbal learning is a process which remains intact well into older adulthood.²⁸ As a result, verbal learning is an ideal cognitive process to examine across the life span with respect to cardiovascular risk and has been established as a key component of cognitive functioning that may be at risk due to elevated triglyceride levels.

The current study attempted to fill a void in the literature on cardiovascular risk and cognitive functioning in several ways: 1) it examines the topic within ethnic minorities, 2) it examines middle-age adults, and 3) it examines the contribution of triglycerides to cognitive impairment. The first aim of the study was to determine whether blood pressure is associated with verbal learning. It was hypothesized that higher systolic and diastolic blood pressure would be associated with poorer performance on 3 domains of the California Verbal Learning Test-II (CVLT-II). The second aim was to determine whether triglyceride levels are associated with verbal learning. It was hypothesized that higher triglyceride levels would also be associated with poorer performance on the CVLT-II.

METHODS

Data Source

Data were collected in conjunction with the National Minority Organ Tissue Transplant Education Program (MOTTEP) *Stress and Psychoneuroimmunological Factors in Renal Health and Disease Study*, which aims to identify biological and psychosocial predictors of renal health outcomes and to reduce the risk of renal disease among African Americans.

Participants

The original sample consisted of 214 community-dwelling African-American men and women. As a result of the triglyceride measurement being added at the 93rd participant, 92 individuals were dropped from the current analysis for a sample size of 121 (Table 1). The sample had a mean age of 43.74 (SD=12.51, range=21-73) and

Table 1. Sample characteristics, blood pressure, triglyceride and CVLT-II outcomes

	M (SD)	Range
Age	43.74 (12.51)	21-73
Years of education	14.16 (2.40)	10-21
Systolic blood pressure (mmHg)	132.92 (17.70)	102.33-204.67
Diastolic blood pressure (mmHg)	78.41 (11.88)	55-120
Triglycerides (mg/dL)	96.01 (65.07)	21-339
List A total recall score (# correct)	43.79 (10.41)	16-64
Short-delay recall score (# correct)	8.57 (3.54)	0-16
Long-delay recall score (# correct)	9.02 (3.68)	1-16

consisted of 45% men and 55% women. Exclusion criteria included current physical, emotional or drug abuse, and a previous diagnosis of a psychological or behavioral disorder. Potential participants were screened by phone and placement in the study was dependent upon self-report regarding the exclusion criteria. The number of potential participants excluded by telephone screening was not recorded. Participants received monetary compensation for completing the study requirements.

Measures

CVLT-II. CVLT-II measures an individual's ability to use semantic associations as a strategy for learning words.²⁹ The CVLT-II word list A consists of 4 categories of words. Each category contains 4 words, for a total of 16 words within the list. For the present study, list A total recall, short-delay free recall, and long-delay free recall were selected as measures of verbal learning. The list A total score was the total number of words recalled across the first 5 learning trials (CVLT-II list A), as an overall index of immediate memory. The short-delay score was the total number of words recalled after the first 5 learning trials and presentation of a second list of distracter words (CVLT-II list B), while the long-delay score was the total number of words recalled from the initial list following a 20-minute delay period. Reliability findings for the CVLT-II are sound. Split-half reliability coefficients for the test were found to range from 0.70–0.86.²⁹ Test-retest reliability of the standard (range=0.80–0.84) and alternative forms (range=0.61–0.73) of the measure are good.³⁰ The criterion validity of the CVLT-II is sound. It successfully distinguishes between varying degrees of severity of diagnosed traumatic brain injury and normal controls.³¹

Procedure

The study required 4–6 hours for completion and took place at the Howard University Hospital General Clinical Research Center (GCRC). Upon arrival at the study facility, participants were given an overview of the study requirements and procedure. All participants completed an IRB informed consent document, demographic information form and health history form.

Assessment of Blood Pressure and Triglycerides

Blood pressure was measured using a Criticare Model 506DXNT sphygmomanometer (VitalCare DOX Model 506DXNT, Criticare Systems, Waukesha, WI). After sitting quietly for several minutes, 1 seated baseline resting measurement was obtained by the nurse on duty at the GCRC. Two subsequent seated blood pressure measurements were taken, 1 following the neuropsychological battery administered for the larger study, and a final measurement taken following the completion of paper-and-pencil psychosocial measures. The average of the 3 blood pressure measurements was calculated and utilized in the analysis. Nonfasting plasma samples were obtained following the baseline resting blood pressure measurement with 21- and 23-gauge syringes. Four vials of blood were drawn for various laboratory assessments within the larger study. Triglyceride levels were determined using standard enzymatic techniques.

CVLT-II Administration

The CVLT-II was administered within a battery of neuropsychological and cognitive assessments by the first author and other graduate students of clinical psychology and neuropsychology. Testing took place at the GCRC following the baseline blood pressure reading and the blood draw. The testing conditions were identical for all participants.

RESULTS

The mean systolic blood pressure of participants was 132.92 mmHg (SD=17.70), and the mean diastolic blood pressure was 78.41 mmHg (SD=11.88). The mean triglyceride level was 96.01 mg/dL (SD=65.07). Sixteen percent of participants reported using hypertension medications, and 5% of participants reported using lipid-lowering medications (Table 1).

The mean number of words recalled correctly for list A total was 43.79 (SD=10.41). The mean numbers of words recalled correctly for short delay and long delay was 8.57 (SD=3.54) and 9.02 (SD=3.68), respectively (Table 2). Blood pressure and triglycerides were significantly related to CVLT-II scores prior to controlling for known covariates. Systolic and diastolic blood

Table 2. Intercorrelations between CVLT-II number of words correct, blood pressure, triglycerides and covariates

	List A Total Recall	Short-Delay Recall	Long-Delay Recall
Systolic blood pressure	-0.30**	-0.23*	-0.24*
Diastolic blood pressure	-0.33**	-0.24**	-0.23*
Triglycerides	-0.30**	-0.29**	-0.28**
Age	-0.31**	-0.33**	0.36**
Gender	-0.25**	-0.24**	-0.23*
Education	0.51**	0.49**	0.49**

* p<0.05; ** p<0.01

pressure were inversely related to CVLT-II performance. Triglycerides were also inversely related to test performance. Age was inversely related to performance on the 3 domains of the CVLT-II. Education was positively related to performance (Table 3).

Two-stage least squares regression analysis was conducted for the 3 CVLT-II domains. Two-stage least squares regression analysis is a method of regression utilized for models that violate the ordinary least squares regression assumption of noncollinearity among predictor variables. This technique was used so that systolic and diastolic blood pressure could be tested in the model simultaneously, despite their strong correlation ($r=0.80$). The predictor variables were systolic blood pressure, diastolic blood pressure, and triglycerides. Age, education and gender were entered into the analyses as covariates. The dependent measures were list A total, short-delay and long-delay recall scores.

It was hypothesized that higher systolic and diastolic blood pressure would be associated with poorer CVLT performance. Systolic blood pressure was not significantly related to any of the CVLT-II domains. Likewise, diastolic blood pressure was not significantly related to any of the CVLT-II domains; however, the relationship between diastolic blood pressure and list A total recall approached significance ($\beta=-0.23$; $p=0.07$) (Table 3).

It was hypothesized that higher triglycerides would be associated with poorer CVLT performance. Higher triglyceride levels were associated with poorer performance for list A total ($\beta=-0.87$; $p<0.01$), poorer performance for

short delay ($\beta=-0.31$; $p<0.01$) and poorer performance for long delay recall ($\beta=-0.32$; $p<0.01$) (Table 3).

Age, gender and education were significantly related to performance on list A total, short delay and long delay recall. Greater age was associated with poorer performance across all 3 domains. More years of educational attainment were associated with greater performance across all 3 domains. Finally, being female was associated with greater CVLT-II performance on all 3 domains (Table 3).

DISCUSSION

The first aim of the current study was to determine whether higher systolic and diastolic blood pressure predict poorer verbal learning performance in a community-based sample of African Americans. Blood pressure was not associated with verbal learning performance. This finding contradicts previous evidence that suggests that blood pressure and verbal learning performance are inversely related.^{12,16,17} In the sample, mean systolic and diastolic blood pressure levels were relatively normal, thus the lack of a relationship with verbal learning performance is not surprising. An examination of extreme blood pressure values (stage-2 or stage-3 hypertension) may have yielded significant relationships for participants with very high or low blood pressure, but the current sample had too few participants that fell into these ranges to perform the appropriate analyses. Ten participants met the criteria for stage-2 or -3 systolic hypertension, and 4 participants met the criterion for stage-2 or -3 diastolic hyperten-

Table 3. Two-stage least squares regression analysis outcomes for list A total recall, short-delay recall and long-delay recall

	Independent Variables	β	SE
List A total recall	Systolic blood pressure	-0.01	0.09
	Diastolic blood pressure	-0.23	0.12
	Triglycerides	-0.87*	0.31
	Age	-0.23*	0.06
	Gender	-40.87*	10.61
	Education	10.83*	0.34
Short-delay recall	Systolic blood pressure	-0.0003	0.03
	Diastolic blood pressure	-0.05	0.04
	Triglycerides	-0.31*	0.11
	Age	-0.09*	0.02
	Gender	-10.66*	0.55
	Education	0.57*	0.12
Long-delay recall	Systolic blood pressure	-0.01	0.03
	Diastolic blood pressure	-0.04	0.05
	Triglycerides	-0.32*	0.11
	Age	-0.10*	0.02
	Gender	-10.71*	0.57
	Education	0.60*	0.12

* $p<0.01$

sion. Because blood pressure was not related to CVLT-II performance in this sample, future research might further explore the functional relationships between blood pressure and memory systems within the brain to determine if a critical age or blood pressure level must be met for this relationship to exist.

The second aim of the study was to explore whether higher triglycerides predict poorer performance on the CVLT-II. This hypothesis was supported. Immediate, short-delay, and long-delay recall performance were poorer at higher triglyceride levels. Higher triglyceride levels have been associated with a decline in verbal knowledge²³ and scores on other psychometric measures.²² This study extends these findings to middle-age African Americans and suggests that elevated lipids, in the form of triglycerides, may be detrimental to memory and learning systems that are associated with diffuse brain areas. The triglyceride results are particularly significant because African Americans, in general, have relatively normal lipid profiles.^{32,33} The findings suggest that, despite relatively normal triglyceride levels among African Americans as a group, the impact of within-group variations in triglycerides levels on cognitive functioning ought to be examined. Triglycerides in plasma are derived from fats eaten in foods or made in the body from other energy sources such as carbohydrates. A previous analysis of the current sample showed that participants in the sample engage in high-fat eating behaviors such as snacking on sweets and emotional eating.³⁴ These eating behaviors may have contributed to the link between triglycerides and verbal learning, possibly as a function of obesity or other factors. Because several factors may have impacted these findings, an in-depth analysis of mediators of the triglycerides and verbal learning link is warranted.

Education accounted for much of the variance in verbal learning performance and may have suppressed some of the impact of blood pressure on cognitive functioning in the sample. This finding is consistent with the cognitive literature. Educational attainment is considered a buffer for cognitive decline. It has been implicated in the “cognitive reserve hypothesis” as a factor which helps to slow cognitive decline across age.³⁵⁻³⁷ The implication here is that because the sample on average has earned greater than a high-school education (many were college graduates), and several participants are at risk for cardiovascular events, educational attainment may have acted as a buffer, thus masking the presence of blood pressure-related cognitive dysfunction.

Age was also a variable that predicted much of the variance in verbal learning performance. This finding would not be unexpected within an older sample. CVLT performance has been associated with age-related decrements, especially beyond the age of 65.²⁸ The question which remains is why age accounted for such a large amount of variance in performance, when the mean age of the sample was 45. The notion of cognitive aging

may help to explain why age was such a salient variable. Cognitive aging describes a pattern of mild impairments in cognitive functioning related to age. While cognitive aging occurs in all individuals, under certain biological or environmental circumstances, cognitive aging is sped up, creating cognitive impairment much earlier in life. Some of the factors which may speed cognitive aging include inflammation, oxidative stress and apoptosis.³⁵ Among African Americans, some additional factors that have been associated with cognitive aging are deficient levels of education, health status, social networks and social engagement.^{38,39} Cognitive aging may help to explain why the verbal learning performance of the sample is prematurely related to age.

Females showed greater verbal learning performance in the study. This finding has been previously demonstrated.^{28,40} One explanation that has been proposed in the literature concerns a possible link between estrogen and verbal learning. Whereas verbal learning declines with age for older females and older and younger males, there is little decline in premenopausal females. This suggests that higher levels of estrogen may play a protective role against age-related memory decline.³⁰

CONCLUSIONS

The current study adds to the body of literature on cardiovascular risk and cognitive functioning by examining African Americans, a group poorly represented in this line of research. It supports the notion that lipids, specifically triglycerides, play a role in cognitive dysfunction. The nonsignificant findings for blood pressure suggest that blood pressure is a distal factor that may not impact cognitive functioning in nonelderly African-American populations, particularly if levels are relatively normal. Future directions for similar studies should include more minority investigations; greater numbers of participants; and the exploration of more cognitive domains, particularly those that impact everyday cognition.

LIMITATIONS

An examination of the relationship among blood pressure, triglycerides and verbal learning is ideally addressed within a longitudinal design. The measurement of blood pressure and triglycerides at a single time point limits the validity of the study results. Future studies should examine these questions in African Americans across several measurements over time.

While nonfasting triglyceride measurement might be seen as a limitation to the current study, there is evidence suggesting that nonfasting lipid levels are as good or better predictors of cardiovascular risk as fasting levels. High levels of nonfasting triglycerides predict myocardial infarction, ischemic heart disease and death.⁴¹ Among women, postprandial, nonfasting triglyceride levels were strongly associated with cardiovascular events independently of other cardiovascular risk factors.⁴²

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