Effects of Health Status on Word Finding in Aging

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OBJECTIVES: To evaluate effects of health status on word-finding difficulty in aging, adjusting for the known contributors of education, sex, and ethnicity.

DESIGN: Cross-sectional.

SETTING: Community.

PARTICIPANTS: Two hundred eighty-four adults aged 55 to 85 (48.6% female) participating in an ongoing longitudinal study of language in aging.

MEASUREMENTS: Medical, neurological, and laboratory evaluations to determine health status and presence or absence of hypertension and diabetes mellitus. Lexical retrieval evaluated with the Boston Naming Test (BNT) and Action Naming Test.

RESULTS: Unadjusted regression models showed that presence of diabetes mellitus was not related to naming. Presence of hypertension was associated with significantly lower accuracy on both tasks ($P < .02$). Adjustment for demographics attenuated the effect of hypertension ($P < .08$). For the BNT, a variable combining presence, treatment, and control of hypertension was marginally significant ($P < .10$), with subjects with uncontrolled hypertension being least accurate (91.4%). Previously observed findings regarding the effects of age, education, sex, and ethnicity were confirmed.

CONCLUSION: In this sample of older adults, hypertension contributed to the word-finding difficulty of normal aging, but diabetes mellitus did not. **J Am Geriatr Soc 57:2300–2305, 2009.**

Key words: language; aging; hypertension; diabetes mellitus

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Difficulty finding the right word at the right moment is a commonly expressed concern of older people. Evidence documenting a progressive reduction in lexical retrieval performance with advancing age has been abundantly provided in studies of language in aging.[1] Demographic factors shown to contribute to this age-related decline in lexical retrieval include sex,[2] education,[3] and ethnicity.[4] Lower education is associated with a more-rapid decline in capacity for lexical retrieval on standardized tests as people get older,[5] and this effect is particularly true for older women with lower education.[6] At older ages, African Americans perform less well on some tests of lexical retrieval than do whites (although see[7]). This might be due to the differences between groups in familiarity with certain items used.[4] When the contributions of ethnicity, sex, and education are eliminated from analysis, age alone is seen to reduce lexical retrieval.[1]

Against this background, the present study was designed to examine the effects of health on lexical retrieval in aging. To the authors' knowledge, no one has previously examined the specific effects on lexical retrieval of two of the most common medical conditions in the aging population: hypertension and type II diabetes mellitus. It was decided to examine these two medical conditions, because they have been shown to influence other cognitive functions in aging,[8,9] and they are potentially controllable.[10]

Hypertension has been linked to reduction in processing speed, reduction in verbal fluency, and impairment of executive function in aging.[8,9,11–13] Diabetes mellitus has been correlated with an accelerated decline in executive system function in independently living elderly persons,[14] as well as with impairments in verbal memory and processing speed.[15] Specifically noted previously is that language functions may be preserved in persons with diabetes mellitus.[15] A life-span analysis of cognition and diabetes proposed that clinically relevant diabetes mellitus–related cognitive decrements occur mainly at two crucial periods in life: in the developing brain of childhood and in the aging brain.[16]

The present study addressed the following question: Does the presence of hypertension or diabetes mellitus have an excess negative effect on the capacity for lexical retrieval

in otherwise normal aging, beyond the effects of sex, ethnicity, and education?

METHODS

Subjects

The Boston University Language in the Aging Brain (LAB) Laboratory recruited 284 healthy adults aged 55 to 84 from several sources, including prior LAB participants,[6] the Veterans Affairs Normative Aging Study,[17] and Boston and the surrounding communities through flyers posted at hospitals, businesses, and community centers and mailings by the Harvard Cooperative Program on Aging. Participants were native English speakers or had learned English before age 7 and used it as their primary language. None had history or evidence of neurological or psychiatric disorder.

Participants were tested between 2004 and 2008. Mean age was 72.0 ± 7.4, mean years of education was 15.0 ± 2.0, and 48.6% were female. Most (88.5%) identified themselves as white; 10.4% as African American.

Procedure

Potential participants completed a telephone screening evaluation to determine eligibility. If eligible, participants were mailed a survey on their health and health-related behaviors to complete before their first of two visits. This survey included demographic characteristics (e.g., age, sex, education, ethnicity, and occupation), as well as health history, health behaviors, health status, and medication use (prescription and over the counter). Based on self-report of a doctor's diagnosis, 44 participants (15.5%) were identified as having diabetes mellitus, and 160 (56.3%) were identified with hypertension; 32 (11.3%) had both.

Before the first visit, participants fasted overnight. During this initial visit, they received medical and neurological examinations and reviewed their health and behavior survey with a nurse or trained research technician. They also provided a fasting blood sample that was analyzed for several biomarkers, including lipids, insulin, glucose, and glycosylated hemoglobin (HbA1c). Blood pressure (BP) was measured four times (twice in each arm) after the participant rested quietly in a chair for 5 minutes, and mean systolic BP (SBP) and diastolic BP (DBP) were computed.

After the medical examination was completed, participants received tests of vision and hearing and began a battery of neurolinguistic and neuropsychological tests, administered by other research technicians blind to the participants' health status. Because of the time involved in testing, half of the tests were given at the first visit and the remainder at a second visit within 5 weeks of the first.

This research complied with all applicable ethical rules and regulations and was approved by the institutional review boards from Boston University Medical Center and Veterans Affairs Boston Healthcare System. All participants provided written informed consent.

Measures

Hypertension and Diabetes Mellitus. For purposes of categorization and subsequent statistical analyses, diabetes mellitus and hypertension were defined in two distinct ways. First, a dichotomous variable (has or does not have the condition) was defined based on the participant's self-report of a doctor's diagnosis on the mailed health survey. Thus, if participants reported having diabetes mellitus or hypertension on this survey, they were considered to have the condition, as is common in studies of health and cognition.[18]

Second, additional information (self-reported medication use, biomarkers) was used to define a more-complex variable that also took treatment and control of the condition into account. Based on the biomarkers of blood pressure and glucose, participants were defined as having high BP if the mean SBP readings were greater than 140 mmHg or mean DBP readings were greater than 90 mmHg[19] and high glucose if their glucose level was 126 mg/dL or higher.[20] If participants reported use of antihypertensive medications (e.g., alpha, beta, or calcium-channel blockers, angiotensin-converting enzyme inhibitors, diuretics) or of insulin, they were defined as being treated for hypertension or diabetes mellitus, respectively. The three indices (self-report of diagnosis, medication use, high biomarker value) were then combined to define five groups for each condition: normal (none of the 3), undiagnosed (no self-report or medication use but high biomarker), diagnosed but untreated (self-report diagnosis but no medication), treated and controlled (diagnosed with medication and normal biomarker), and treated and uncontrolled (given the diagnosis and being treated, but the treatment was not effective, as documented by high biomarkers).[12,21] Table 1 presents the distribution of this five-level classification for hypertension and diabetes mellitus.

To further assess the validity of this classification, Table 1 also presents results of one-way analyses of variance for selected demographics (age, education) and biomarkers of hypertension (blood pressure, high-density lipoprotein cholesterol (HDL-C)) and diabetes mellitus (glucose, HbA1c, and insulin). As would be expected, those without hypertension had lower BP, similar to those whose hypertension was controlled. Persons with undiagnosed or uncontrolled hypertension had higher BP, especially SBP. For diabetes mellitus, the situation was similar; glucose was lowest in those without diabetes mellitus, as was HbA1c. Glucose in subjects with diabetes mellitus did not differ depending on treatment or control, although those who did not have diabetes mellitus had significantly lower glucose. Those who were uncontrolled had a higher mean HbA1c level, a measure of longer-term (3 months) control of diabetes mellitus, than those who were normal, undiagnosed, or controlled. Insulin was highest in those with undiagnosed or controlled diabetes mellitus and lower among those did not have diabetes mellitus or had untreated or uncontrolled diabetes mellitus.

Naming. Two tests of naming were selected from the neurolinguistic and neuropsychological battery employed in the LAB laboratory for analysis: the Action Naming Test (ANT)[22] and the Boston Naming Test (BNT).[23] In the ANT, participants were asked to name the action depicted in 57 simple black-and-white line drawings that appeared one at a time on a computer screen. Similarly, in the BNT, participants were asked to name each of 60 objects depicted in simple black-and-white line drawings that appeared on the computer one at a time. For both tests, if no response was given after 20 seconds or an incorrect response was given, the research assistant gave the participant a semantic or phonemic cue.

For both tests, only correct responses before any cue were counted. A percentage correct score was computed for each test: the number of correct responses before cue divided

Table 1. Selected Demographics and Biomarkers According to Diagnosis, Treatment, and Control of Hypertension or Diabetes Mellitus

Variable	Normal	Undiagnosed	Untreated	Controlled	Uncontrolled	P-Value (F)*
Hypertension (n = 279)						
Subjects with hypertension, %	28.7	6.4	6.1	45.2	13.6	
Age	70.6	71.4	72.1	72.9	72.2	.32
Education, years	15.4[a]	15.0[ab]	13.8[c]	15.1[ab]	14.2[bc]	<.001
Systolic blood pressure, mmHg	118.6[a]	148.2[c]	132.4[b]	123.3[a]	149.1[c]	<.001
Diastolic blood pressure, mmHg	67.0[a]	76.0[c]	70.0[ab]	66.8[a]	73.4[bc]	<.001
High-density lipoprotein cholesterol, mg/dL	60.0[a]	54.8[ab]	57.3[ab]	50.1[bc]	46.3[c]	<.001
Diabetes mellitus (n = 284)						
Subjects with diabetes mellitus, %	82.8	1.8	4.6	4.2	6.7	
Age	72.5[ab]	74.0[a]	71.9[ab]	67.1[b]	68.7[ab]	.03
Education, years	15.1	14.2	14.9	13.9	14.7	= 28
Glucose, mg/dL	95.8[b]	138.6[a]	139.2[a]	104.1[a]	152.9[a]	<.001
Glycosylated hemoglobin, %	5.6[c]	6.3[bc]	6.7[ab]	6.3[b]	7.2[a]	<.001
Insulin, µIU/mL	7.8[b]	23.7[a]	7.1[b]	18.9[a]	12.0[b]	<.001

Note: Within a given row, means with the same superscript (e.g. "a") were not statistically different from one another ($P > .05$) by Duncan's multiple range (test). For example for education, means with superscript "a" do not differ from one another, but do differ from means with superscript "b" or "c".

* P-value for F test from analysis of variance comparing levels of diabetes mellitus or hypertension.

by the number of items administered. Because the ANT and BNT were administered during separate testing sessions, fewer participants completed the ANT (i.e., did not return for the second testing session). A total of 276 completed the BNT, and 254 participants completed the ANT.

RESULTS

All analyses were performed using SAS version 9.1 (SAS Institute, Inc., Cary, NC). Regression was used to examine the effects of disease on naming. First, whether naming differed between those who did and did not have the disease (based on self-report of a doctor's diagnosis) was examined; these analyses were conducted with and without adjusting for demographic characteristics. Next, whether naming varied between the five levels of disease classification was examined, adjusting for demographics and for the presence or absence of the other disease (based on the self-report of a doctor's diagnosis). Age and education were included as covariates, as well as ethnicity and sex because these may be independently linked to performance on naming tests.[4] To examine the effects of potential confounders, the effects of depression, psychiatric medication, their combination, and use of other medications were also considered.

Self-Reported Diagnosis

First, whether naming was related to the presence or absence of hypertension or diabetes (defined according to self-report of a doctor's diagnosis) was considered. As shown in Table 2, persons who reported having hypertension performed significantly worse on both naming tasks. The unstandardized regression estimates (b) indicate the effect of the disease variable on the naming task, adjusted for other variables in the model. Also shown are the standard errors and the associated P-values for the coefficient. For example, the first b, − 1.259, indicates that hypertension was associated with a 1.3% lower accuracy ($P = .01$) on the ANT, and this effect was statistically significant. For the BNT,

hypertension resulted in performance that was 2.2% less accurate ($P < .01$). For both naming tasks, the hypertension diagnosis accounted for approximately 2.5% of the variance in the scores. For diabetes mellitus, the effect of a self-reported diagnosis was not significant for either naming task.

Table 2 also shows the effects of hypertension and diabetes mellitus on the naming tasks, adjusted for the demographic variables. For hypertension, the models accounted for 10.1% of the variance in ANT scores and 25.5% in BNT scores, although the effects of a hypertension diagnosis were marginally significant ($.05 < P < .08$), indicating that persons with hypertension, adjusted for age, education, sex, and ethnicity, were somewhat ($\sim 1\%$) less accurate on both naming tasks, but here the finding was a trend. As previously reported,[6,24] for similar but not overlapping samples, education was positively associated with both naming tasks, and age was negatively associated, as was ethnicity. On the BNT, women were less accurate than men, especially women with less education, and there was an interaction between age and education, such that more years of education offset some degree of aging loss on naming objects (results not shown).

For diabetes mellitus (Table 2), although the models including the demographic characteristics were significant, having a diagnosis of diabetes mellitus was not significantly associated with performance on either naming task. As was the case for hypertension, education was positively associated with both naming tasks; age and identifying oneself as African American were negatively associated. For the BNT, women, especially with lower education, performed worse, and there was a positive effect of education for older individuals (results not shown).

Self-Reported Diagnosis, Including Treatment and Control

The effects of the five-level classification, which incorporated aspects of diagnosis, treatment, and control of hyper-

Table 2. Regression Coefficients (Unstandardized) Demonstrating the Effect of Hypertension or Diabetes Mellitus on Naming (Percentage Accuracy)

Variable	ANT	BNT
	β (Standard Error) *P* value	
Hypertension		
Unadjusted	− 1.259 (0.486) .01	− 2.218 (0.815) .007
Adjusted for demographics*	− 0.861 (0.484) .08	− 1.375 (0.755) .07
Five-level classification (adjusted for demographics* and presence of diabetes mellitus)		
Normal	Reference	Reference
Undiagnosed	− 0.318 (1.029) .76	1.278 (1.578) .42
Untreated	− 0.262 (1.097) .82	1.896 (1.694) .27
Controlled	− 0.812 (0.604) .18	− 1.268 (0.920) .17
Uncontrolled	− 0.604 (0.821) .47	− 1.842 (1.254) .15
Diabetes mellitus		
Unadjusted	− 0.387 (0.682) .57	0.808 (1.133) .48
Adjusted for demographics*	− 0.338 (0.707) .64	0.041 (1.078) .97
Five-level classification (adjusted for demographics* and presence of hypertension)		
Normal	Reference	Reference
Undiagnosed	1.555 (1.749) .38	2.368 (2.822) .40
Untreated	0.335 (1.144) .77	1.193 (1.762) .50
Controlled	− 0.712 (1.344) .60	− 0.630 (2.024) .76
Uncontrolled	− 0.140 (1.016) .90	0.224 (1.532) .89

*For Action Naming Test (ANT), demographics are age, education, female sex, and ethnicity. For Boston Naming Test (BNT), interactions between female and years of education and between age and years of education were also included.

tension and diabetes mellitus on naming, were then examined (Table 2). These models included the four demographic variables (age, education, sex, and ethnicity) and, for BNT, selected interactions between them; the five-level diagnosis (as 4 dummy variables, using persons without the condition as the reference group); and the presence of the other condition (based on the dichotomous self-reported diagnosis). For example, for the model with the five-level hypertension classification, the presence of diabetes mellitus was included in the model. For hypertension, this model explained 10.6% of the variance in ANT and 27.6% in BNT.

For ANT, the five-level hypertension classification was not significant, nor was the presence of diabetes mellitus. Worse performance on action naming was found for older persons, African Americans, and those with less education (all $P < .05$). Women were marginally less accurate ($P = .07$).

For BNT, the five-level hypertension classification was marginally significant ($P < .10$). Post hoc comparisons (using least-square means) indicated that people with uncontrolled hypertension (91.4%) were less accurate ($P < .05$) than those with untreated hypertension (95.1%) and marginally worse ($P < .10$) than those with undiagnosed hypertension (94.6%); people with controlled hypertension (92.0%) were marginally less accurate than those with undiagnosed (94.5%) or untreated (95.1%) hypertension (both $P < .10$). All demographic variables were significant for this model, indicating that older persons, women, Af-

rican Americans, and those with less education performed worse. More education somewhat reduced the negative effect of age and sex. The presence of diabetes mellitus was not related to BNT accuracy.

For diabetes mellitus, the five-level classification variable was not significant for either naming task (BNT or ANT). As with hypertension, ANT accuracy was positively associated with education and negatively associated with age and ethnicity (all $P < .05$). Having hypertension was marginally related ($P = .08$) to lower ANT accuracy. These variables explained 10.6% of the variance in ANT accuracy.

For BNT, as with hypertension, the demographic factors and presence of hypertension explained 25.9% of the variance in BNT accuracy. Lower performance was associated with older age, female sex, and African-American ethnicity; greater education attenuated some of the negative effects of sex and age.

The analyses described in Table 2 were repeated, adjusting for possible effects of depression history, treatment, or symptoms; use of psychiatric medications; their interaction; and use of other medications. Because none of these potential confounds was significant, the results of these analyses are not reported.

DISCUSSION

This study demonstrated a negative effect of hypertension on lexical retrieval in older adults, even after the potentially confounding effects of ethnicity, sex, and education were controlled for. Contrary to expectations, no effect of diabetes mellitus on naming was found. With regard to the effects of hypertension on the brain and its consequences for cognition, research has suggested that microvascular changes in frontal system white matter pathways affect executive system function, leading to cognitive impairments in normal aging.[8,9,11–14,25–28] Specifically focusing on deficits in lexical retrieval, we have hypothesized that progressive executive system dysfunction due to impaired frontal system connectivity in persons with high cerebrovascular risk factors contributes to word finding difficulties in aging. The present study is consistent with this hypothesis. When the research participants were classified on the basis of diagnosis of hypertension (presence or absence), a statistically significant, independent contribution of hypertension to word-finding difficulty was found. Even when the more-complex schema regarding diagnosis, treatment, and control of disease was generated, a trend approaching statistical significance was found.

The unexpected and counterintuitive absence of effects of diabetes mellitus on lexical retrieval in aging can only be speculated about. Here, two alternative, and testable, hypotheses for future consideration are offered. The first has to do with possible differences between the nature and location of cerebrovascular changes in hypertension and diabetes mellitus. It may be the case that hypertension causes microvascular changes located primarily in frontal system white matter, whereas diabetes mellitus causes vascular changes in larger cerebral vessels, and these changes are less likely to be concentrated primarily in frontal white matter. If the key to lexical retrieval deficit in normal aging is impairment in executive system functioning because of frontal white matter disturbance, as proposed, then

according to this hypothesis, hypertension would be more likely than diabetes mellitus to cause the frontal system dysfunction required for impairment of lexical retrieval.

A second possibility, equally worth exploring, is that the cognitive deficits of aging generally attributed to diabetes mellitus are not due to cerebrovascular disease at all, but are due, rather, to the effects on brain function of diabetes mellitus–related metabolic dysfunction, such as insulin resistance or impaired glycemic control, as may be considered, for example, in the metabolic syndrome. Although not yet comprehensively considered in the scientific literature, this notion deserves further exploration, because it may lead to preventative treatment programs.

In sum, hypertension was found to be an additional factor contributing to word-finding difficulty in normal aging, beyond the effects of age per se, education, sex, and ethnicity. Diabetes mellitus, in contrast, did not influence lexical retrieval in this study. A report on the protective effect of tight antihypertension control on cognitive function in aging offers hope that such treatment may also be helpful in preventing decline in lexical retrieval in normally aging persons.[29] With hypertension affecting 73 million people in the United States and approximately 1 billion people around the world,[30] improvement in management of this disorder may have direct benefit to capacity for communication in elderly people and improvement in their quality of life.

ACKNOWLEDGMENTS

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