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J Am Geriatr Soc. Author manuscript; available in PMC 2008 November 19.

Published in final edited form as:
J Am Geriatr Soc. 2008 November 1; 56(11): 2014–2019. doi:10.1111/j.1532-5415.2008.01938.x.

Cognitive Status and Physical Function in Older African Americans

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Abstract

OBJECTIVES—To investigate the relationship between global cognition, three specific domains of cognition, and lower extremity function in community-dwelling elderly African Americans (AAs) from two community settings.

DESIGN—Cross-sectional study.

SETTING—Community.

PARTICIPANTS—Ninety-six AA men and women aged 60 and older from two community settings, enrolled in the Boosting Minority Involvement (BMI) study, a community-based cohort study designed to increase research participation of older low-income AAs.

MEASUREMENTS—Physical performance was assessed using Short Physical Performance Battery score, which is composed of three timed tests: a 4-m walking task, static balance assessment, and a chair stand test. The Bushke Memory Impairment Screen (MIS) and Mini-Mental State Examination were used to assess global memory and global cognition, respectively. For domain-specific performance, three *z*-score composite scores (attention, verbal memory, and executive function) were developed using the Computer-based Assessment of Mild Cognitive Impairment.

RESULTS—All domains of cognition were significant predictors of lower extremity function except for verbal memory. Executive function and MIS were the best predictors of lower extremity function in adjusted models. Participants with poor executive function were more than four times as likely to have poorer lower extremity function (odds ratio = 4.96, 95% confidence interval = 1.07–23.0).

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Author Contributions: M. L. Nieto: study design, acquisition of subjects and data, analysis and interpretation of data, and preparation of manuscript. S. M. Albert: study design, analysis and interpretation of data, revision of the manuscript for important intellectual content, and final approval of the version to be published. L. A. Morrow and J. Saxton: interpretation of data, revision of the manuscript for important intellectual content, and final approval of the version to be published.

Conflict of Interest: The editor in chief has reviewed the conflict of interest checklist provided by the author and has determined that the author has no financial or any other kind of personal conflicts with this manuscript. This study was funded by a grant from the National Institute on Aging (Grant T32 AG 021885) and Claude D. Pepper Older Americans Independence Center (P30 AG024827). Dr. Saxton is a Consultant to Eisai Medical Research Inc., and Forest Research Institute.

Sponsor's Role: None.

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CONCLUSION—Global memory and executive function were the best predictors of lower extremity function in a sample of community-dwelling AA adults. Deficits in lower extremity function may depend on multifaceted higher executive function control processes.

Keywords

executive function; lower extremity function; African American; community setting

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Poorer cognitive and physical functions are prevalent age-related conditions that result in disability in instrumental and basic activities of daily living, hospitalization, and admission to nursing homes.[1–3] Cross-sectional studies have shown an association between cognition and physical performance.[3–8] Previous studies have postulated that cognitive decline affects gait and increases the risk of falls, in particular when there is evidence of impaired executive function.[9–11] Executive functioning encompasses a series of high-level processes. In particular, executive function is defined as the cognitive ability to perform complex goal-directed behaviors that facilitate adaptation to new or other complex situations when highly practiced cognitive abilities no longer suffice.[12]

Age-related decline in cognition, including executive function, has been well documented,[13,14] but information on the relationship between domain-specific cognition and lower extremity performance in older African Americans (AAs) is limited. In addition, domain-specific predictors of lower extremity function may help in guiding medical decision-making in elderly people with declining physical function. For instance, elderly patients who have poor cognitive function might be managed more aggressively for fall prevention than those with decreasing physical performance but better cognition.

The aim of the study was to examine the relationship between global memory and global cognition, three specific domains of cognition, and lower extremity function in elderly community-dwelling AAs from two community settings. The association between executive function and lower extremity function was examined, and in particular, determination of the strength of this association was sought, adjusting for performance in other cognitive domains.

METHODS

Study Sample

This research used baseline cross-sectional data from the Boosting Minority Involvement (BMI) study, a community-based cohort study designed to increase research participation of older AAs from low-income communities in mobility, cognition, and physical function assessments. Participants were recruited from four community centers and four county-sponsored low-income senior housing buildings in Pittsburgh, Pennsylvania, and were assessed at baseline, 6 months, and 12 months. The sites were chosen because they have a high concentration of elderly AAs and were in low-income neighborhoods.

Eligible participants were AAs aged 60 and older attending community centers or living in county-sponsored senior housing. Participants were excluded if they had a terminal medical condition, had plans to move out of the area within 12 months, or had severe cognitive impairment based on a Bushke Memory Impairment score of less than four.[16] It was decided to exclude these participants because it was desired to assess the relationship between specific domains of cognition and physical performance without the possible confounder of severe cognitive impairment. The institutional review board of the University of Pittsburgh approved the study protocol, and each participant provided written informed consent for participation in the study.

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Measures

Outcome: Physical Performance—Physical performance was assessed using Short Physical Performance Battery (SPPB) score. The SPPB score is composed of three timed tests: a 4-m walking task, static balance, and a chair stand test.[17,18] Timed results from each test were scored from 0 (worst performers) to 4 (best performers). The sum of the results from the three categorized tests (ranging from 0 to 12) was used for the present analyses as a continuous outcome variable. This scale has good reliability and validity for predicting mortality, hospital admission, activity of daily living decline, and physical disability.[17–19]

In particular, walking speed was evaluated, measuring the participant's usual gait speed in meters per second over a previously measured 4-m course. The time needed to walk the 4 meters was recorded using a digital stopwatch. Four-m gait speed was assessed twice, and the average time from the two trials was used for the total score. Participants unable to complete the task were scored 0. In the chair stand test, participants were asked to stand up from a chair with their arms across their chest five times in a row as fast as possible. Subjects unable to complete the test received a score of 0. To assess balance, participants were asked to perform three increasingly difficult standing positions: side-by-side, semi-tandem, and tandem. Participants were asked to hold each position for 10 seconds. Participants unable to complete the test were scored 0. A trained research assistant determined whether it was safe for the participant to perform each task.

Explanatory Variables: Cognitive Performance—Global memory and cognition were assessed using the Memory Impairment Screen (MIS)[16] and the Mini-Mental State Exam (MMSE),[20] respectively. The MIS involves registration and recall of four words with semantic category priming; it is scored on a scale of 0 (worst) to 8 (best). This test has been validated to assess Alzheimer's disease and other dementias.[16] The MMSE consists of 30 questions that assess orientation, attention, immediate- and short-term recall, language, and the ability to follow simple verbal and written commands. Scores range from 0 (worst) to 30 (best).

Domain-specific cognition was assessed using the Computer-based Assessment of Mild Cognitive Impairment (CAMCI). The CAMCI collects data in a standardized fashion that is presented on a Tablet PC with touch screen response and takes approximately 20 minutes to complete. [21,22] The sensitivity and specificity were found to be 0.79 and 0.67, respectively. The sensitivity and specificity are based on 521 normal community-dwelling adults aged 65 and older who had the CAMCI plus a battery of paper and pencil tests. The CAMCI assesses verbal and nonverbal memory, executive function, attention, psychomotor speed, working memory, and secondary memory. For domain-specific performance, three *z*-score composite scores were developed (attention, verbal memory, and executive function). It was decided to use these three domains to be consistent with prior studies.[2,4–6,23–25] The grouping of selected tests to form a composite score was based on conceptual grounds and in consultation with a neuropsychologist. For all tests, participants were given a set amount of time to complete assessments.

The assessments for the attention domain included a simple targeted detection task, Digit Forward Span, and Part 1 of the Tracking Test. In the target detection paradigm, the star task, respondents were instructed to respond to an infrequently occurring stimulus. That is, the participant was shown a star, a circle, a square, and a triangle and asked to tap on the screen as quickly as possible when the star was presented. Participants were scored on number correct out of 16 targets. In the Digit Forward Span task, participants heard a series of numbers, one per second, and after presentation were asked to tap the numbers in the same order on a number display (1 through 9) presented on the bottom of the computer screen. The series began with three numbers, and two trials were presented for each number series up to a span of six. The task was discontinued if errors were made on two consecutive series of the same number. The

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longest series with at least one correct was the obtained score. For Part 1 of the Tracking Test, the computer displayed numbers 1 through 22 in circles, and the participant was asked to connect the string of 22 numbers in ascending order by tapping on the screen. The score was number correct out of 22.

Assessment of the verbal memory composite domain included word recognition, word recall, and itemized recall. For word recognition, a list of six words appeared on the screen, one at a time. The participant was instructed to look at each word and try to remember it, because they would be asked to recall it at a later time. After a delay interval, four words were displayed, three distracters and the target word, and the task was to tap on the target word shown previously. Scores could range from 0 (worst) to 6 (best). For word recall, participants were presented with a series of five three-letter words (e.g., toe, spy, elk, mop, bat), one at a time, and were also asked to remember them. The words were presented in a series three times. Recall of the words was tested after several intervening tests by asking participants to type the five three-letter words they had been shown. A letter keyboard was presented at the bottom of the screen for the participants to type the words on. Recall was scored on scale of 0 (worst) to 5 (best). Itemized recall was assessed by showing the participant a list of grocery shopping items (i.e., bread, bananas, donuts, and shampoo) and then after a delay interval having the participant pick which item they had been told to recall from among a series of distractor items (e.g., eggs, soap).

Assessment of the executive function composite domain included a go/no go task, Reverse Digit Span, and Part 2 of the Tracking Test. For the go/no go task, participants were asked to tap the screen twice if they heard one beep and once if they heard two beeps. The rules were then changed, and participants were asked to tap twice if they heard one beep and do nothing if they heard two beeps. The target score was number correct on the second trial, during which they had to inhibit their response. Scores ranged from 0 to 10, with lower scores indicating poorer executive function. For the Reverse Digit Span, participants heard a series of numbers and were then asked to tap the numbers on a display on the bottom of the computer screen in the reverse order. The series started with two digits and increased in difficulty up to six digits. The task was discontinued if errors were made on two consecutive series of the same length. The longest series with at least one correct was the obtained score. On Part 2 of the Tracking Test, the computer displayed a series of numbers and months in circles, and participants were asked to connect the circles on the screen alternating between months forward, January through December, and numbers in reverse order, 12 to 1. The total score was number correct.

Covariates

Explanatory variables included age, sex, education (dichotomized for the analysis as < high school education vs ≥high school education), and comorbidity index (determined by summation of self-reported illnesses, including cerebrovascular disease, hypertension, diabetes mellitus, coronary heart disease, congestive heart failure, macular degeneration, glaucoma, depression, arthritis, osteoporosis, asthma, peripheral neuropathy, Parkinson disease, and history of cancer).

Statistical Analysis

Descriptive statistics were used to describe the study population. Univariate and multivariate linear regression models were developed to examine the association between cognitive performance and lower extremity function, adjusting for age, sex, education, and comorbidity index. After establishing the predictive value of each independent cognitive domain, stepwise adjusted ordinary least squares regression models were developed to examine the association between lower extremity function and each independent cognitive domain. The first model included the full model with all cognitive domains, adjusting for age, sex, education, and

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comorbidity index. The final model included only significant predictors of lower extremity function, adjusting for age, sex, education, and comorbidity index. *P* <.05 was considered significant. Summed *z*-score composites were transformed to center the mean at 0.

Logistic regression models were developed to examine cognitive predictors of lower extremity function. For these analyses, the SPPB was dichotomized as poor (SPPB score < 9, 44.8% of sample) and good (SPPB9) physical performance. The executive function domain was dichotomized at less than 1 standard deviation to indicate poor executive function. The full model included MIS, MMSE, and executive function, adjusting for age, sex, education, and comorbidity index. The likelihood ratio test was used to test the association between executive function and lower extremity function. All analyses were performed using the Intercooled STATA statistical software package version 10 for Windows (Stata Corp., College Station, TX).

RESULTS

The study population baseline characteristics are presented in Table 1. The study sample (N = 96) had a mean age of 72.9 ± 7.7 and was predominantly female (78%). Forty-eight percent reported education after high school. Most participants were overweight or obese (mean body mass index of 30.2 ± 6.2), with 45% widowed, 67% living alone, and 76% reporting a history of hypertension.

Descriptive statistics for global memory, global cognition, the three cognitive domains of function, and SPPB are presented in Table 2. All domains of cognition were significantly correlated, but diagnostic tests in regression analyses suggest that the collinearity assumption was not violated (e.g., the variance inflation factor was < 2.0).

Cognition and Lower Extremity Performance

Univariate models adjusted for age, sex, education, and comorbidity index are summarized in Table 3. All domains of cognition were significantly associated with lower extremity function except for verbal memory (*P* = .06). The MIS and executive function had the highest beta coefficients (0.33 and 0.62, respectively).

Adjusted models developed in a stepwise regression are summarized in Table 4. After adjusting for age, sex, education, and comorbidity index, only MIS was significantly associated with lower extremity function, although attention, executive function, and MMSE met the preset criteria of $P \leq .30$ to be subsequently included in the third stepwise regression model. In this model, attention had a *P*-value > .30 and was dropped from the model. The fourth model included global memory and cognition (MIS and MMSE) and executive function, although only executive function and MIS were significantly associated with lower extremity function. The final model including global memory (MIS) and executive function explained 45% of the variability in SPPB. As suspected, age and comorbidity index were also significantly associated with lower extremity function. Adjusting the models for a vascular risk factor covariate did not significantly change the results, and the vascular risk factor was not a significant independent correlate.

Risk of Poor Lower Extremity Performance Associated with Executive Function

Logistic regression models to determine the association between executive function and lower extremity function independent of global cognition showed that people with poor executive function (1 standard deviation below the mean) were more than five times as likely to have poorer lower extremity function (odds ratio (OR) = 5.3, 95% confidence interval (CI) = 1.58–17.79 in the unadjusted model). Adjusting for MMSE and MIS attenuated the association (OR

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= 4.88, 95% CI = 1.26–18.98). The final model, which adjusted for global memory (MIS), global cognition (MMSE), age, sex, education level, and comorbidity index, continued to show that people with poor executive function were more than four times as likely to have poorer lower extremity function (OR = 4.96, 95% CI = 1.07–23.0).

DISCUSSION

This study evaluated the association between global memory, global cognition, three specific domains of cognition, and lower extremity function in elderly community-dwelling AAs from two community settings. The results of the study showed an association between executive function and lower extremity function independent of global memory, global cognition, age, sex, educational level, and comorbidity index. This study confirms previously reported associations between physical function and executive function.[4–9] Previous studies reporting the association between executive function and physical function have not reported the percentage of AAs or whether minority groups were included in the investigation.[4,23,26] To the authors' knowledge, the only study that has addressed the relationship between cognition and physical function in AA was done in healthy middle-aged participants.[6]

Despite previous studies showing an association between attention and physical performance,[10,26] the current study did not confirm attention as a significant predictor of physical function (Table 3). This might reflect the fact that this study did not focus exclusively on gait speed as the main outcome of physical function but incorporated all components of the SPPB for comprehensive assessments of lower extremity function.

Studies investigating the association between specific domains of cognition have shown associations between executive function involving dual- and single-task performance,[4,5,23,24,26] but these studies had a sample of healthy older adults with low prevalence of diseases, including hypertension, diabetes mellitus, asthma, arthritis, and cardiovascular disease, and did not adequately reflect the aging population in the United States. Our findings suggest that, even in a population with multiple chronic diseases and low socioeconomic status, executive function and global memory are significantly associated with physical function independent of number of comorbidities, age, sex, and educational level.

Participants with poor executive function were more than four times as likely to have poor physical performance as people with better executive function. This finding suggests that lower extremity function, including gait and balance, may in part depend on multifaceted higher cognitive demands and require higher-order executive function control processes. Furthermore, studies that show that cortex activation in brain areas involved in higher cognitive control in intentional and goal-oriented behaviors[27,28] have refuted the long-held belief that locomotion is an automatic movement without much input from higher-order cognitive processes,[29,30] although additional explanations addressing the relationship between executive function and processing speed of each task performed should be considered. In the current study, categorizing each component of the SPPB and using speed as the main outcome increased variability but did not improve the predictive value of each cognitive domain.

Lower extremity structural cortical controls have not been well established, although some studies suggest that the underlying mechanism for gait is multifactorial and in old age involves use of higher-order executive function processes. Moreover, studies have shown that poor balance and gait in elderly people are related to atrophy of the frontal and temporal lobes.[31] Decreased mobility and gait dysfunction in elderly people has also been associated with periventricular white matter abnormalities.[32,33] A mechanistic paradigm suggests a motor control network regulated by higher-level executive function that includes the prefrontal cortex for control of locomotion behaviors and a higher-level, "supervisory" attention system that

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allows for modulation of the activities in the first level in a flexible and adaptive way.[34–37] However, as people age and experience hearing and visual problems, integrity of executive function may be essential for fine tuning previously learned automatic locomotion tasks. Studies suggest that polymodal sensory association areas in the brain, such as the posterior parietal lobes and superior temporal gyrus, as well as the hippocampus and parahippocampus areas, are required to perform previously learned behaviors.[38,39] Patients with Alzheimer's disease have three times the rate of falls as elderly people without dementia.[40,41] In addition, one study showed that poorer lower extremity function was a precursor to vascular dementia and therefore worse executive function.[42] This suggests that decline in cognitive function, including executive function, may contribute to the greater fall risk in patients with lower cognitive reserve.

Limitations of this study include the use of a volunteer sample and cross-sectional data that do not allow assessment of the causal relationships. Longitudinal studies in AAs assessing the mechanism by which executive function affects physical performance with aging are needed to identify therapies and preventive treatments.

ACKNOWLEDGMENT

We thank Charity Reid for her assistance with participant recruitment and data collection. Psychology Software Tools, Inc. developed the software for the CAMCI.

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Table 1

Baseline Characteristics of the Participants N = 96

Characteristic	Value
Age, mean ± SD	72.88 ± 7.66
Sex, %	
Female	78.1
Male	21.9
Education, %	
< High school	18
High school	34
Vocational	5
Any college	39
Graduate school	3
Body mass index, mean ± SD	30.2 ± 6.2
Recruitment site, %	
Community center	74
Senior high rise	26
Marital status, %	
Single	17
Married	16
Divorced	22
Widowed	45
Living alone, %	67
Comorbidities, %	
Cerebrovascular disease	10
Hypertension	76
Diabetes mellitus	31
Coronary heart disease	22
Congestive heart failure	12
Macular degeneration	7
Glaucoma	16
Depression	6
Arthritis	64
Osteoporosis	14
Asthma	16
Peripheral neuropathy	12
Parkinson disease	2
History of cancer	15

Note: The proportion of comorbidities was assessed according to self-report.

The mean comorbidity index was 3.5 ± 1.9.

SD = standard deviation.

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Table 2

Descriptive Statistics of Global Cognition, Three Domains of Cognition, and Short Physical Performance Battery (SPPB)

Variable	Mean ± Standard Deviation
Global memory and cognition	
Memory Impairment Screen score	6.44 ± 1.34
Mini-Mental State Examination score	26.35 ± 2.70
Specific cognitive domains	
Attention (raw score)	
Star task (# correct)	15.68 ± 0.64
Digit Forward Span (score)	5.78 ± 1.61
Part 1 Tracking (# correct)	21.14 ± 5.38
Verbal memory (raw score)	
Word recognition (# correct)	5.34 ± 0.94
Word recall (# correct)	1.95 ± 1.15
Itemized recall (# correct)	3.44 ± 1.43
Executive function (raw score)	
Go/No Go task (# correct)	7.48 ± 2.98
Reverse Digit Span (score)	3.64 ± 2.25
Part 2 Tracking (#correct)	17.81 ± 8.12
SPPB	9.24 ± 2.55

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Table 3

Univariate Association Between Short Physical Performance Battery, Each Independent Cognitive Domain, Global Cognition, and Global Memory (N = 96)

Variable	β	*P*> |z|	95% Confidence Interval
Attention	.24	.02	0.023–0.466
Verbal memory	.19	.06	0.009–0.398
Executive function	.33	.001	0.159–0.509
Memory Impairment Screen	.61	.001	0.282–0.944
Mini-Mental State Examination	.30	.001	0.143–0.455

Univariate models were adjusted for age, sex, education level, and comorbidity index.

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Table 4

Association Between Short Physical Performance Battery and Each Independent Cognitive Domain in Stepwise Adjusted Regression Models

Variable	Model 1	Model 2	Model 3	Model 4
	Odds Ratio (95% Confidence Interval)			
Age	−0.10 (−0.15 to −0.04)*	−0.10 (−0.15 to −0.04)*	−0.10 (−0.16 to −0.05)*	−0.10 (−0.15 to −0.04)*
Sex	−0.56 (−1.56–0.45)	−0.56 (−1.56–0.44)	−0.57 (−1.56–0.43)	−0.55 (−1.55–0.45)
Education	−0.38 (−1.24–0.50)	−0.35 (−1.21–0.51)	−0.33 (−1.19–0.52)	−0.26 (−1.12–0.58)
Comorbidity index	−0.36 (−0.59 to −0.13)†	−0.36 (−0.58 to −0.13)†	−0.38 (−0.59 to −0.16)*	−0.36 (−0.57 to −0.14)*
Cognitive measures				
Attention	0.13 (−0.11–0.36)	0.11 (−0.12–0.34)		
Verbal memory	−0.06 (−0.28–0.16)			
Executive Function	0.18 (−0.04–0.40)	0.17 (−0.04–0.40)	0.22 (0.03–0.41)‡	0.28 (0.11–0.45)†
Memory Impairment Screen	0.44 (0.09–0.79)†	0.44 (0.09–0.79)†	0.42 (0.08–0.79)†	0.50 (0.18–0.82)†
Mini-Mental State Examination	0.13 (−0.06–0.32)	0.12 (−0.07–0.30)	0.12 (−0.07–0.30)	
Coefficient of determination	0.47	0.46	0.46	0.45
Adjusted coefficient of determination	0.41	0.42	0.42	0.42

* $P < .001$

† $P < .01$

‡ $P < .05$.