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Education and Physical Activity Mediate the Relationship between Ethnicity and Cognitive Function in Late Middle Aged Adults

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Abstract

Objective—Minority status has been implicated as a risk factor for disparate scores on cognitive function tests in older adults. Research on ethnicity and cognitive function has yielded socioeconomic status (SES), particularly education, as a primary reason for the discrepancy. Other factors, such as physical activity may provide insight into the relationship. Despite this knowledge, few studies have thoroughly examined the mediating characteristics of education or physical activity in the relationship between ethnicity and cognitive function in younger aged groups. Most research conducted focuses only on older adults during a time when degeneration of brain tissue may complicate the exploration of the relationships among ethnicity and cognitive function. The current research will expand existing knowledge about education, physical activity, and cognitive function in minority groups.

Design—The study presents data from the Health and Retirement Study, a nationally representative sample of late middle aged white, black, and Hispanic adults ($n=9,204$, mean age $\pm$ $sd=55.8\pm3.1$). Regression and mediation testing determined the mediating effects of education and physical activity in the relationship between ethnicity and cognitive function.

Results—Significant association between white ethnicity and higher scores on cognitive tests was evident as early as late middle age. The magnitude of the association significantly diminished on adjusting for education and leisure time physical activity.

Conclusion—Our data suggest a potential mediating role of education and physical activity on the ethnic differences in cognitive tests in late middle aged white, black, and Hispanic adults. Our findings suggest a need for studies to understand if adult education and culturally-appropriate physical activity interventions in middle age influence ethnic disparities in prevalence of cognitive impairment in old age.

Introduction

Approximately 5.4 million United States adults over the age of 71 experience some form of cognitive impairment without dementia (Plassman 2008). Mild cognitive impairment precedes dementia with an annual conversion rate to Alzheimer's disease of approximately 15 percent compared to one percent in those without mild cognitive impairment (Petersen *et al.* 2001). Furthermore, decline in cognitive function has been listed as one of the top fears that adults have about the aging process (Reese *et al.* 1999, Friedenberg 2003, Hess 2006). Compounding these fears is the fact that cognitive decline is associated other problems (e.g. increased risk of disability, loss of independence, and premature deaths) (Moritz *et al.* 1995,

Grenier *et al.* 1996, Leveille *et al.* 1008), even in middle age (Pavlik *et al.* 2003). These issues are of particular concern because research shows that impairment in cognitive function may disproportionately affect underrepresented/underserved groups in the U.S. such as African Americans.

One approach to preventing late-life-cognitive impairment is to understand factors associated with preservation of cognitive function during the transition from middle to old age. For example, research has shown that cognitive decline is slower for those with high levels of social networks and social activities (Barnes *et al.* 2004). Thus, research about other modifiable factors affecting the onset or worsening of cognitive impairment is a key to preventing cognitive disability. In particular, preventing late-life cognitive impairment requires a thorough understanding of mid-life factors associated with cognitive decline. Recent longitudinal studies in white populations have shown that late-life dementia is associated with the presence of hypertension, obesity, diabetes, low education, and physical inactivity in mid-life (Kivipelto *et al.* 2005, Kivipelto *et al.* 2006). These mid-life factors are amenable to interventions even in late-life (Alcalay *et al.* 1999, Larson *et al.* 2006).

Ethnicity, Physical Activity, Education, and Cognitive Function

In addition to the ethnic disparity in cognitive impairment, the cardiovascular and lifestyle factors described are highly prevalent in Hispanic and black populations (Crespo *et al.* 1996, Black *et al.* 1999). For example, data from the National Health and Nutrition Examination Survey showed 33% of Mexican-American men, 46% of Mexican-American women, and 40% of black women engaged in no leisure time physical activity (Crespo *et al.* 1996). Another study showed that Mexican Americans have a disproportionately high age-adjusted prevalence of metabolic syndrome, an independent predictor of accelerated cognitive decline (Ford *et al.* 2002, Yaffe *et al.* 2007). The high prevalence of metabolic syndrome, physical inactivity, and other factors affecting cognition may, at least in part, account for lower scores on tests of cognitive function among Hispanic and black adults compared with whites (Zsembik and Peek 2001, Sloan and Wang, 2005).

However, little is known about how disparities in education and differences in physical activity levels in mid-life affect late-life cognitive function in blacks and Hispanics. Such knowledge may point to ways to reduce the incidence and disparities in cognitive impairment in old age. Previous research that supports this investigation includes findings from the MacArthur Studies of Aging that identified correlates of cognitive decline (Albert *et al.* 1995). The researchers noted that subjects who had higher levels of education or engaged in strenuous activities had greater preservation of their cognitive function over time and that the effect of lower education on cognitive function diminished when the analyses accounted for strenuous activity (Albert *et al.* 1995). In the same study, strenuous activity intervened in the relationship between race/ethnicity and cognitive decline in that the black/white disparity in decline was lessened when strenuous activity was included in the model (Albert *et al.* 1995).

Several gaps exist in the research on ethnicity and cognitive function in late middle aged adults. First, very little research exists on the disparities in cognitive function in mid-life (Zsembik and Peek 2001, Barnes et al 2003). It is important to examine potential health disparities in mid-life so that future research and interventions aimed at eliminating any documented disparities can be appropriately targeted to middle aged and older adults. Second, the few studies on cognitive disparities between black and white older adults did not include Hispanics, a fast growing segment of the US population (Zsembik and Peek 2001, Albert et al 1995). It is critical to determine if other minorities, such as Hispanics, suffer from the same disadvantage so that interventions to eliminate disparities and future research

can target the correct groups. Third, the impact of physical activity (a factor shown to differ by ethnic group and cognitive function scores) and educational attainment on diminishing the perceived association between ethnicity and cognitive scores in mid-life, especially among blacks and Hispanics, has been largely unexplored.

Research Objectives

The current study addressed some of the gaps in ethnicity-cognition research by investigating the potential mediating role of modifiable mid-life factors (education and physical activity) in a nationally representative sample of white, black, and Hispanic late middle aged adults. Using the conceptual path diagram in Figure 1, we sought to determine if:

1. ethnic disparities in cognitive function scores exist as early as late middle age,
2. education mediated (attenuated) the relationship between ethnicity and cognitive function, and if
3. physical activity mediated (attenuated) the relationship between ethnicity and cognitive function.

Methods

Data

The data were from the longitudinal Health and Retirement Study (HRS). Data collection began in 1992, and continues biennially, with a multistage area probability sample (n=12,654) of male and female US adults and their household members aged 51 and older (Juster and Suzman 1995). For the current study, the sample size was restricted to those aged 51-61 at baseline (n=9,892), who did not respond with the assistance of a proxy (n=9,407), and who identified themselves as white, black, or Hispanic (9,204). The final sample (n=9,204) included 1,612 black and 869 Hispanic participants. In addition, in 1996 new activity and cognitive measures were added to the survey, so 1996 data on the same sample were analyzed to account for those changes. Those remaining from the original sample numbered 7,944.

Proxy respondents did not answer the same cognitive function or physical activity questions (among others) as other respondents. These variables were critical to the analyses and therefore respondents who answered by proxy were excluded. There were just under 500 proxy respondents at baseline. They were compared by demographic variables and stroke status. Because stroke is so closely related to cognitive function, if more proxy respondents suffered from a stroke than the regular sample, the participants in the current analyses might have better cognitive function overall than those who were excluded. Cochran Mantel Haenszel and t-tests were used to compare proxy respondents to non-proxy respondents. There were no differences in age, education, income, or stroke status. However, proxy respondents were more likely to be married (OR=4.07; $p<0.0001$), and were also more likely to be male (OR=2.56; $p<0.0001$).

In order to account for the over sampling of three distinct subgroups (residents of Florida, black, and Hispanic participants), sampling weights created for HRS 1992 data were used in the current study. Furthermore, the HRS weight for each participant was adjusted by the use of a propensity score, the probability of being included in the sample selected for the current analyses (Rosenbaum and Rubin 1983). This is a practice common in similar research (Wolinsky 2007).

Measures

Cognitive function measures were two assessment tools administered in either English or Spanish by trained interviewers – items from the Telephone Interview of Cognitive Status (Brandt *et al.* 1988), representing “mental status,” and word recall items, representing “memory.” Memory items were asked of participants beginning in 1992, and mental status items were added in 1996. The clinical utility of cognitive screening tools such as these is limited; however, it has been suggested that they can be used to confirm or refute a diagnosis of mild cognitive impairment in the event that a clinician is unable to complete all portions of a patient's assessment (i.e. interviewing a close friend or relative) (Knopman *et al.* 2003).

Memory—was tested using the combination of two measures: immediate recall and delayed recall. For immediate recall, respondents were read a list of 20 words and asked to recall as many as they could. After five minutes of additional questions, respondents were asked to recall any words from the list of 20 that they could remember, indicating their delayed recall score. Principal Components Analysis with no rotation (results not shown) was used to examine whether the immediate and delayed recall questions were independent measures of cognitive function. The measures were found to be highly associated and produced a single factor solution with both measures loading on the first factor. Reliability analyses produced a Cronbach's coefficient alpha of 0.85. Therefore, the immediate and delayed items were converted into a factor score and standardized for use in the analyses (range -2.53-5.34).

Mental status—items were derived from the Telephone Interview of Cognitive Status (Brandt *et al.* 1988). In previous research, the Telephone Interview of Cognitive Status has been shown to be useful in screening for dementia (Gatz *et al.* 2002); however some research reports that the most useful and least biased items are those that deal with word recall, the other measure in the current study (Manly 2006). The mental status items included orientation questions (current date, day of the week, month, and year), two object naming questions, counting backwards from 20, and naming the president and vice president of the United States for a total possible score of 10. The mean (SD) score for the sample was 9.32(1.06). In order to ensure that the data met regression assumptions for normal distribution, a kernel density plot and skewness and kurtosis values were computed. The data were moderately skewed to the left, so the variable was transformed to produce a mean of zero and a standard deviation of one. Analyses were re-run using this data transformation and no significant differences were found in the models.

In addition, using Principal Components Analyses (PCA) with no rotation (results not shown) and testing for reliability showed that the items did not load on a single factor measuring “cognitive function” (Cronbach's coefficient alpha=0.51). This showed us that the mental status measures were independent and not redundant and could not be combined to create a reliable scale. In the current research, therefore, the mental status score should be interpreted as a count of mental status indicators of orientation, concentration, and naming, rather than a scaled test of cognitive function.

Ethnic bias in the cognitive measures was also addressed prior to analyses. First, reliability of the measurements was examined within each ethnic group. Overall, the Cronbach's alpha reliability and factor loadings for the different cognitive function items were similar across ethnic groups indicating comparable internal consistency. Second, it was confirmed that the major correlates of cognitive function (e.g. education) were correlated in the same direction for each ethnic group. In addition, the correlates of cognitive function were associated in the same direction with memory and mental status score by ethnic group (results not shown). Though validity is not addressed and the absence of measurement error has not been

established, the results suggest that proceeding with the analyses is appropriate because the scores are comparable by ethnic group. Therefore, the analyses were completed using the single factor score for memory and the HRS-created summary score for mental status.

Demographic variables—included participants' age, sex, ethnicity (white, black, or Hispanic), marital status, education, household income, and work status. Education was measured as the number of years of school a participant reported completing. This measure was used as both a continuous (0-17) and categorical (<8 years, 8-11 years, 12 years, 13 years) variable in the models and no differences were found. Household income (quartiles) was comprised of respondents' earnings, unemployment and Workers' Compensation, pensions and annuities, Social Security income and welfare, capital income, disability income, other income received by the respondents, and income of other household members. Working for pay that year or not, and being married or not were accounted for as dichotomous variables.

Health related and social variables—included body mass index (BMI) calculated from self-reported height and weight in categories based on the World Health Organization (2008) classifications, participation in physical activity, self-report of doctor diagnosis of heart disease, stroke, diabetes, or hypertension, depressive symptoms (derived from the Centers for Epidemiologic Studies-Depression scale (Radloff 1977)) and church attendance (attending religious services zero times in the past year, one or more times per year, 2-3 times per month, once a week, or more than once a week (Range 0-4)). Some demographic and health measures differed in the analyses for memory in 1992 and the analyses for mental status in 1996 (see Table 1b).

In 1992, physical activity measures included questions about frequency of light, vigorous, and housework activity. For example, “*How often do you participate in vigorous physical exercise or sports -- such as aerobics, running, swimming, or bicycling?*” Participants could respond that they engaged in these activities 3 or more times a week, 1 or 2 times a week, 1 to 3 times a month, less than once a month, or never (range 0-4). In 1996, the respondents were asked if they participated in vigorous physical activity or exercise three times a week or more. This dichotomous response replaced the three questions about leisure and housework activity frequency in 1992. In addition, for the mental status analyses, we used the 1996 data for household income, work status, diagnosis of comorbidities, and depressive symptoms (see Table 1b).

Analyses: Multivariable modeling of memory and mental status outcomes

All analyses were completed using SAS 9.1 (2008). Descriptive statistics were presented by study wave and differences among racial and ethnic groups were detected with ANOVA, Chi-Square and Likelihood Ratio tests.

To assess the cross sectional mediating effects of physical activity and education in the relationship between ethnicity and cognitive function, general linear models and Sobel tests were conducted (Sobel 1982). These were completed using data from 1992 (memory) and again using 1996 data (mental status) for reasons previously stated. The reason for testing mediation is to try to understand the mechanism through which ethnicity appears to be associated with cognitive function. As declared by Baron & Kenny (1986), in order to be considered a mediator, physical activity (or education) must be associated with ethnicity, cognitive function must be associated with ethnicity, and physical activity (or education) must be associated with cognitive function. The effect of ethnicity on cognitive function must be reduced when education and/or physical activity are entered into the models (Preacher and Hayes 2004). In order to assess this, a Sobel test was conducted to determine

if the approximate indirect effect of ethnicity on cognition via physical activity or education was different from zero (Sobel 1982, Baron and Kenny 1986). This is consistent with similar research conducted by researchers using the Duke EPESE (Sachs-Ericsson and Blazer 2005).

In the mental status analyses, variables that were again collected in 1996 (such as income, and body mass index) were included in the models. If the variable was only collected in 1992 (such as ethnicity), the 1992 value was utilized. See Tables 1a and 1b for a more detailed explanation.

Results

Table 1a presents characteristics of our sample at baseline. Sample participants were 73% white, 18% black, and 10% Hispanic. The average education level was 12 years. In 1992, over 50% reported engaging in light physical activity three times per week or more, with 13% reporting vigorous activity engagement and 8% reporting housework activity participation. In the 1996 sample, 50% of participants reported engaging in vigorous physical activity three times per week or more.

Because white participants had greater levels of education and leisure time physical activity than black or Hispanic participants (Table 1a), the first criterion for mediation was met. In order to establish the second criterion for mediation, multivariable regression models predicting memory and mental status scores were completed (Tables 2 and 3).

Memory Score

Table 2 presents general linear model estimates of the relationship between ethnicity and memory scores in 1992. The results show that throughout the model building process, ethnicity was associated with memory score. With regard to education, those who had lower levels of education had lower scores on the memory test than those who were educated beyond 12 years of school. Greater levels of both light and vigorous activity were also associated with higher memory scores ($p < 0.01$). Because education, light, and vigorous physical activity were associated with memory score, even in multivariable models, the second condition for mediation was met.

The third condition for mediation is that the relationship between ethnicity and cognitive function is diminished in the presence of education or physical activity. One can see this demonstrated visually in models 4, 5, and 6 of Table 2, but in order to know if the decrease is significant or not, Sobel tests were conducted. The test results indicated that in the multivariable models, number of years in school significantly reduced the magnitude of the relationship between both black and Hispanic ethnicity and memory score ($z = -7.80$; $p < 0.0001$ and $z = -8.72$; $p < 0.0001$, respectively). Results were similar for physical activity. The inclusion of vigorous and light physical activity in the model significantly reduced the magnitude of the relationship between black and Hispanic ethnicity and memory score ($z = -3.26$; $p = 0.001$ and $z = -3.24$; $p = 0.001$, respectively for vigorous activity; $z = -2.87$; $p = 0.001$ and $z = -2.69$; $p = 0.001$, respectively for light activity).

Mental Status Score

Table 3 shows the results of multivariable regression models of the relationships for mental status score. Variables were added to the models in the same pattern as with memory.

The results indicate that ethnicity was associated with mental status score throughout the models, a finding similar to memory score. Model 4 showed that having less than high school education was associated with lower mental status score. Mental status score (unlike

the 1992 memory score) was not associated with leisure time physical activity after adjustment for all of the other variables (see Model 5). These results show that the second criterion for mediating was met for education, but not for physical activity.

Models 4 and 5 adjusted for education and physical activity respectively to examine the effect on the magnitude of the relationship between ethnicity and mental status. In Model 4, the magnitude of the relationship between ethnicity and mental status was reduced once adjusted for education. This significant reduction for both black and Hispanic ethnicity was confirmed with a Sobel test for mediation ($z = -10.64$; $p < 0.0001$ and $z = -13.41$; $p < 0.0001$, respectively). In Model 5, physical activity was not significantly associated with mental status, nor did its inclusion have an effect on the model fit statistic.

Discussion

The purpose of this research was to examine the relationships between ethnicity and cognition in mid life. Our hypotheses were that there would be ethnic disparities on scores of cognitive function, and that the disparities would be mediated by education and current physical activity. Our findings supported our hypotheses in that we found a significant association between white ethnicity and higher scores on cognitive tests as early as late middle age. Furthermore, the association's magnitude diminished on adjusting for education and physical activity, signifying education and physical activity as partial mediators of the association. To our knowledge, this is the first study that specifically investigates mediators of ethnic disparities in cognitive scores in middle-age.

Our findings are similar to previous studies suggesting a relationship between ethnicity and cognitive scores in older adults (Sloan and Wang 2005, Albert *et al.* 1995). For example, data from the Asset and Health Dynamics of the Oldest Old (AHEAD) study showed that white ethnicity was a significant predictor of higher scores on cognitive tests in persons aged 70 and older (Sloan and Wang 2005). Our analysis of Health and Retirement Study data adds to the AHEAD study by providing information on ethnic disparities in scores on cognitive tests, as well as mediators of those scores, in one important subgroup of individuals – men and women in early to late middle age.

Previous research on older adults showing physical activity and education level as partial mediators of ethnic differences in cognitive scores that support this investigation and findings include results from the MacArthur Studies of Aging (Albert *et al.* 1995). Study data showed that strenuous activity partially explained the relationship between ethnicity and cognitive decline with narrowing of ethnic-cognition differences after adjusting for strenuous activity (Albert *et al.* 1995). The current study extended past research by showing that education and light and vigorous leisure time physical activity are partial mediators of the ethnicity-cognition association in a younger, nationally representative, multi-ethnic sample. The use of such a sample, and the inclusion of sampling weights, allows the results to be generalized to late middle aged adults in the United States.

The results also provide additional evidence that certain types of physical activities (leisure versus household) are associated with improved cognitive function, and the cognitive effects of physical activity may differ by cognitive domain (memory vs. mental status) being assessed. This information is very useful to cognitive aging researchers as future intervention studies may need to determine which cognitive domains are most impacted by various interventions. Because levels of education and physical activity were not sufficient to suggest complete mediation, it is important that other potentially modifiable mediators be investigated. These mediators may also differ by ethnic groups.

The mediating effect of education between ethnicity and cognitive function was supported in the current research and is consistent with previous research showing that education has a substantial impact on the relationship (Zsembik and Peek 2001, Sachs-Ericsson and Blazer 2005). This was not surprising given that education disparities among black, Hispanic, and white persons are so well documented, and that education has been shown to be a significant predictor of better cognitive function in previous research (Albert *et al.* 1995, Scherr *et al.* 1988, Evans *et al.* 1993, Farmer *et al.* 1995).

There are several reasons why education is related to cognitive function. First, education may lead to a longer latent period of cognitive decline by directly affecting the brain's structure during early developmental years (Stern *et al.* 1999). Second, education contributes to the development of skills that support the thinking and mental strategies required for certain kinds of cognitive tests (Mirowsky and Ross 2003). Furthermore, low levels of education may be accompanied by poorer health behaviors and illnesses that can affect cognitive function (Albert 1995). Although adding years of schooling toward late middle and old age is often an unrealistic intervention, educational programs to enhance thinking strategies such as the ACTIVE Trial (Jobe *et al.* 2001) or to improve health behaviors can be easily incorporated into programs that target late middle or older aged groups, especially ethnic minorities (Alcalay *et al.* 1999).

In our study, education completely mediated the disparity from whites in mental status scores in middle-aged Hispanics, but not in middle-aged blacks. This finding suggests that education has a bigger impact on cognitive scores among middle-aged Hispanics than middle-aged blacks, even when adjustments were made for social and economic factors. Previous research supports this finding. Using data from the National Education Longitudinal Study, Goldsmith (2003) analyzed the effects of school segregation in the early 1990's on test scores. Results showed that being in a highly segregated school was positively associated with test scores for Hispanic students, but negatively associated with test scores for black students. Reasons for the differential effect included the notion that immigrant parents have been shown to have optimism about their children's' potential success and can be very encouraging, and that Latino students are less likely than black students to come from single parent homes (Goldsmith 2003, Kao and Tienda 1998).

Ethnic differences in scores on cognitive function screening tests are complex in that cognitive tests reflect more than intrinsic cognitive ability. Performance on the tests also reflects cultural bias as well as disparities in language of testing, literacy and quality and years of formal education (Manly 2006, Jones 2003). There were several possible mediating factors that were not ascertained and if they were, may have had an impact on the results. These issues are related to educational differences and stereotype threat. Though education is an important measure of socioeconomic status, an element considered a fundamental cause of disease (Link and Phelan 1995), years of education or degree obtained are not necessarily sufficient to explain the educational differences between white and minority adults in the United States (Manly 2006). Some research suggests that, specifically in cognitive function studies, quality of education and literacy are more relevant to the outcome than years of education or degree obtained (Manly *et al.* 2002, Albert and Teresi 1999). In a Northern Manhattan Aging study, almost 400 white and black older adults aged 65 and older answered naming, memory, and reasoning questions as part of a cognitive battery (Manly *et al.* 2002, Gurland *et al.* 1999). When adjusting for education, black adults had significantly lower scores on the cognitive function test than white adults. However, when accounting for reading level, as measured by the Wide Range Achievement Test (Jastak and Wilkinson 1984), in some cases, the differences were no longer statistically significant. Literacy may have assisted research participants with word recognition and memory portions of the test (Manly *et al.* 2006).

Quality of education is another concept that may help to explain ethnic differences in scores on cognitive tests (Manly 2006). Those who were educated before school desegregation, or who obtained their education in poorer areas of the country, may not have received the same quality of education as a person who went to a wealthier, more progressive, or private school (Kaufman *et al.* 1997). If education is thought to contribute to cognitive function scores by contributing to the development mental strategy skills, such as memorization techniques (Mirowsky and Ross 2003), quality of education or educational facility can impact that development. In the current study, no additional measures that assessed quality of education or reading level were included and therefore could not be adjusted for in statistical models. Future waves of the HRS should include more comprehensive measures related to education such as reading ability or level and scholastic quality. In addition to measures of socioeconomic status, cultural factors may also explain some of the variance in the relationship between ethnicity and cognitive function.

Finally, Steele and colleagues have suggested that perceived racism or “stereotype threat” may contribute to disparities in scores on tests of cognitive function (Steele and Aronson 1995, Steele 1997), and this idea has been cited by a number of researchers as a potential explanation of ethnic differences in cognitive function found in their studies (Zsembik and Peek 2001, Manly 2006, Osborne 2001). Some research has shown that black and Hispanic research participants, sensitive to stereotypes that they are not cognitively advanced, may perform worse on cognitive function and knowledge tests if they are told that their intellectual ability is being tested (Steele and Aronson 1995, Steele 1997, McKay *et al.* 2003, Gonzales *et al.* 2002). The addition of perceived discrimination measures might illuminate the presence of stereotype threat.

Past studies have documented associations between physical activity and improved cognitive function and brain plasticity, possibly leading to delaying of cognition-impairing diseases (e.g. Alzheimer's) (van Gelder *et al.* 2004). However, survey participants in published studies are often all one ethnic group or all one gender (van Gelder *et al.* 2004, Weuve *et al.* 2004). Albert and colleagues (1995) demonstrated that in older adults aged 70-79 strenuous physical activity may mediate the effect of ethnicity on cognitive function in a large sample of older adults; our study extended their findings to a large tri-ethnic sample of middle aged adults (aged 51-61). As noted in our study, housework activity was not a mediator for either outcome, and physical activity level did not mediate the relationship between ethnicity and mental status score. One explanation for the latter finding may be that the measurement of physical activity in 1996 may not have been as accurate as in 1992 because the dichotomous variable did not allow for a variety of responses. Baron and Kenny (1986) reported that in the case of measurement error of the mediator, the effect of the potential mediator can be underestimated. Because of this and because of the effects of light and vigorous activity on the memory score, the results support closer examination of the mediating effects.

There were several study limitations in addition to the inconsistency of measurement of physical activity. The cross-sectional nature of the data prohibits a directional interpretation of the results. Furthermore, although the complex sample design was employed to ensure that the sample was nationally representative, we can not rule out the possibility of a Type I error in our results. In addition, the HRS documentation reports that the mental status items were derived from the Telephone Interview of Cognitive Status (TICS) (Brandt *et al.*, 1988, Ofstedal *et al.* 2005), however, the small list of items does not fully capture the domains measured by TICS or any modified TICS versions. Though the reliability did not vary by ethnic group, the mental status items are not a scale of cognitive function. Thus, it is possible that the additional effect of ethnicity on cognitive function scores that was unexplained was due, at least in part, to measurement bias. And, as previously discussed, the

HRS does not include supplementary information about the quality of the participants' education or literacy levels, measures that may have made the findings about education and its mediating role more robust (Manly 2006).

Education, physical activity, and mental status measures could be coded in a variety of ways. In order to confirm that changes to those variables would have little or no effect on the results, several sensitivity analyses were conducted. Education was coded as a continuous and categorical measure with no significant changes to results.

In addition to education, physical activity has been used by other HRS researchers in different ways. It has been reported that there are no differences in physical activity by ethnicity in the Health and Retirement Study when physical activity measures are used as a scale (He and Baker 2005). One purpose of the study was to uncover the types of activities that were positively associated with cognitive function. If all measures of physical activity are combined into one score, an opportunity is missed to examine the effects of different types of physical activity on cognitive function.

Though the variety of physical activity measures allowed for a broader assessment of the kinds of physical activity in which study participants engaged, the measures decreased in number and variability after Wave I. Respondents were given several choices when answering questions about their light, vigorous, and housework. However, in 1996, the housework and light activity variables were removed and the response to the vigorous activity measure became dichotomous. Participants could only say if they engaged in vigorous exercise 3 times a week or more, or not. This led to a substantial increase in positive responses. When given several options, 13% of the sample said they engaged in vigorous activity 3 times per week or more. Conversely, in 1996, when given fewer options, over 50% reported engaging in that much activity. Physically active people who did not actually meet the criteria of exercising vigorously 3 times per week or more may have been reluctant to say that they did not engage in that much activity. This problem with self-reported physical activity may have led to a diminished effect of activity on cognitive scores in 1996.

Finally, it is important to note that other health behaviors that impact cognitive function were considered in the current research. Both casual alcohol consumption and cigarette smoking behaviors were explored as potential model variables. Neither was found to have an impact on the main research questions and both were consequently removed from analysis so as not to over-saturate the models.

It is not clear whether increasing just any cognitive and physical activities will reduce the onset of cognitive decline and subsequent dementia. Future research should focus on specific types of light and vigorous leisure time physical activities as mediators of the relationship between ethnicity and cognitive function. More community-based studies are needed to understand the effects of adult education and activity initiatives in middle age in reducing ethnic disparities in prevalence of cognitive impairment, with the goal of creating strategies to prevent or delay the onset of cognitive and physical disability in old age. These types of studies may lead to a greater understanding of how different ethnic groups should be targeted with specific interventions tailored to reflect the most up to date research.

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Key Messages

(1) We found a significant association between white ethnicity and higher scores on cognitive tests as early as late middle age. (2) The association's magnitude diminished on adjusting for education and physical activity, signifying education and physical activity as partial mediators of the association. (3) To our knowledge, this is the first study that specifically investigates mediators of ethnic disparities in cognitive scores in middle-age. (4) Our findings are consistent with previous studies suggesting a relationship between ethnicity and cognitive scores in older adults.

Figure 1. Conceptual relationships among race/ethnicity, education, physical activity, and cognitive function in a multi-ethnic sample of late middle aged adults.

TABLE 1a
Baseline descriptive statistics by racial/ethnic group for participants in the Health and Retirement Study (1992) (n=9204). Values in Mean (sd)/%

	White (n=6273)	Black (n=1612)	Hispanic (n=869)		White (n=6273)	Black (n=1612)	Hispanic (n=869)
Age *	55.88 (3.14)	55.87 (3.10)	55.60 (3.11)	Church attendance *			
Male *	45.96	40.07	43.15	Never	24.06	9.64	10.38
Married [†]	80.68	56.20	73.76	Once a year or more	24.90	17.80	21.34
Household income [†]	\$52,883 (\$57,478)	\$34,146 (\$60,713)	\$28,613 (\$32,651)	2-3 times per month	14.18	23.63	18.87
HH Income Q1	18.73	42.01	47.08	Once a week	22.85	25.90	33.02
HH Income Q2	24.18	24.65	27.22	More than once a week	14.00	23.03	16.39
HH Income Q3	28.13	18.36	13.32	Physical Activity [†]			
HH Income Q4	28.97	14.97	12.38	Light			
Education *	12.67	11.31	8.53	3+/Week	54.48	48.08	47.07
<= 8 years	2.89	10.36	41.20	1-2/Week	22.06	19.85	20.02
8-11 years	17.79	32.38	24.40	1-3/month	8.51	8.37	10.01
11 years	39.48	31.51	16.57	< 1/month	7.21	7.57	6.79
13+ years	39.85	25.74	17.84	Never	7.73	16.13	16.11
Working [†]	67.84	60.07	54.00	Vigorous			
Stroke [†]	2.38	4.53	3.22	3+/Week	14.23	9.00	10.59
Heart Disease [†]	13.15	14.33	9.67	1-2/Week	10.83	7.57	7.02
Diabetes [†]	8.79	17.74	15.07	1-3/month	9.36	5.52	5.29
Hypertension [†]	35.71	57.57	39.24	< 1/month	21.21	13.96	9.78
CESD Symptoms (0-8) [†]	1.63 (1.21)	2.00 (1.42)	2.23 (1.73)	Never	44.37	63.96	67.32
BMI [†]	26.78 (4.85)	28.88 (6.14)	27.92 (5.13)	Housework			
Underweight	1.25	1.36	1.38	3+/Week	6.87	11.17	15.54
Normal Weight	36.69	22.52	26.58	1-2/Week	19.90	24.19	24.05
Overweight	40.79	40.20	43.73	1-3/month	22.10	19.23	17.72
Obese	21.27	35.92	28.31	< 1/month	27.99	18.86	13.12
Memory (0-20) *	13.67 (5.04)	10.34 (4.42)	10.8 (4.66)	Never	23.13	26.55	29.57
Mental Status (0-10) [†]	9.52	8.72	8.72				

* Significantly different by race/ethnicity at p<0.05 (ANOVA for Age, Memory, and Mental Status; Chi square and Likelihood Ratio tests for other variables)

[†] Mean provided from 1996 data (baseline for mental status analyses)

[†] 1996 values utilized in mental status models

TABLE 1b
Baseline sample characteristics from the Health and Retirement Study for the study of
the relationship between race/ethnicity, physical activity, and cognitive function

VARIABLE	HRS 92	HRS 96	VARIABLE	HRS 92	HRS 96
	(n=9204)	(n=7944)		(n=9204)	(n=7944)
Mental Status (0-10) *	n/a	9.32 (1.06)	Church attendance *		
Memory (0-40) *			Never	20.17	19.49
(unstandardized)	12.81 (5.09)	n/a	Once a year or more	23.31	23.35
Mean (SD) Age *	55.85 (3.13)	59.76 (3.14)	2-3 times per month	16.3	16.32
% Female *	55.33	56.43	Once a week	24.4	24.76
Race/ethnicity *			More than once a week	15.82	16.07
White	73.04	74.50	Physical activity *		
Black	17.51	16.67	Light Physical Activity		
Hispanic	9.44	8.84	3+/Week	52.66	n/a
Mean Education *	12.04 (3.19)	12.13 (3.15)	1-2/Week	21.48	n/a
<8 years	7.81	7.39	1-3/month	8.63	n/a
8-11 years	20.97	20.32	< 1/month	7.24	n/a
12 years	35.92	35.96	Never	10.00	n/a
13+ years	35.30	36.33	Vigorous Physical Activity		
Mean HH Income *	\$47,331 (56,969)	\$53,321 (76,572)	3+/Week	12.87	50.56
% Working for pay *	65.18	53.28	1-2/Week	9.96	n/a
% Married *	75.74	76.54	1-3/month	8.64	n/a
% Stroke *	3.27	4.05	< 1/month	20.08	n/a
% Diabetes *	11.42	13.45	Never	48.44	n/a
% Hypertension *	40.83	43.94	Heavy House Work		
% Heart Disease *	14.36	16.49	3+/Week	8.44	n/a
Mean Depressive Symptoms (0-8) *	1.75 (1.32)	1.29 (1.88)	1-2/Week	21.05	n/a
BMI *			1-3/month	21.19	n/a
Underweight	1.28	1.18	< 1/month	24.99	n/a
Normal Weight	33.26	33.33	Never	24.34	n/a
Overweight	40.96	40.95			
Obese	24.50	24.53			

Notes:

* Significantly different by race/ethnicity at p<0.05 (ANOVA for continuous variables; Chi square and Likelihood Ratio tests for other variables)

Table 2

Results of Multivariable (OLS) Regression Models of the Relationship between Race/Ethnicity and Memory Score in the Presence of Covariates Among Late Middle Aged Adults (n=9204) in the Health and Retirement Study (1992).

Model Variables	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6		Model 7	
	Beta	SD	Beta	SD	Beta	SD	Beta	SD	Beta	SD	Beta	SD	Beta	SD
Intercept	0.18	0.01	1.59	0.22	1.83	0.22	1.66	0.21	1.56	0.22	1.56	0.21	1.66	0.21
Hispanic	-0.549	0.04	-0.431	0.04	-0.404	0.04	-0.191	0.04	-0.188	0.04	-0.191	0.04	-0.191	0.04
Black	-0.649	0.03	-0.546	0.03	-0.525	0.03	-0.452	0.03	-0.448	0.03	-0.449	0.03	-0.452	0.03
Education <8							-0.80	0.05	-0.78	0.05	-0.78	0.05	-0.80	0.05
Education 8-11							-0.51	0.03	-0.49	0.03	-0.50	0.03	-0.51	0.03
Education 12							-0.26	0.03	-0.25	0.03	-0.25	0.03	-0.26	0.03
Vigorous Activity									0.03	0.01				
Light Activity											0.03	0.01		
House Activity													-0.001	0.01
R ²	0.052		0.122		0.133		0.172		0.174		0.173		0.173	

Notes: Model 2=Model 1 + age, gender, income, work status, marital status. Model 3=Model 2 + stroke, heart disease, diabetes, hypertension, bmi, depressive symptoms, church attendance. Models 4-7 are adjusted for all previous covariables.

* p<0.05

** p<0.01

*** p<0.001

Table 3

Results of Multivariable (OLS) Regression Models of the Relationship between Race/Ethnicity and Mental Status Score in the Presence of Covariates Among Late Middle Aged Adults (n=7944) in the Health and Retirement Study (1996).

Model Variables	Model 1		Model 2		Model 3		Model 4		Model 5	
	Beta	SD	Beta	SD	Beta	SD	Beta	SD	Beta	SD
Intercept	9.53	0.01	9.29	0.24	9.45	0.23	9.34	0.22	9.35	0.22
Hispanic	-0.750	0.06	-0.564	0.05	-0.550	0.05	-0.253	0.06	-0.254	0.06
Black	-0.763	0.05	-0.630	0.05	-0.612	0.05	-0.535	0.04	-0.535	0.04
Education <8							-1.03	0.08	-1.03	0.08
Education 8-11							-0.44	0.04	-0.44	0.04
Education 12							-0.15	0.02	-0.15	0.02
Vigorous Activity									-0.02	0.02
R ²	0.085		0.121		0.133		0.185		0.185	

Notes: Model 2=Model 1 + age, gender, income, work status, marital status. Model 3=Model 2 + stroke, heart disease, diabetes, hypertension, bmi, depressive symptoms, church attendance. Models 4 & 5 are adjusted for all previous covariables.

* p<0.05
 ** p<0.01
 *** p<0.001