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The Relationships among Race/Ethnicity, Physical Activity, Education, and Cognitive Function in Late Middle Age

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The Relationships among Race/Ethnicity, Physical Activity, Education, and Cognitive Function in Late Middle Age

by

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Dedication

This work is dedicated to my parents, Kristin and Paul Wilson, for your support and encouragement throughout my life. Thank you for all you have given to me.

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The Relationships among Race/Ethnicity, Physical Activity, Education, and Cognitive Function in Late Middle Age

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OBJECTIVES: This study describes cross-sectional and longitudinal racial/ethnic differences in cognitive function scores (memory and mental status), and the mediating roles of education and physical activity in late middle aged adults. The purpose of the study is to explain racial/ethnic disparities in cognitive function scores. **METHODS**: The Health and Retirement Study collected data on men and women aged 51-61 in the United States from 1992-2002 (n = 9204) of the following racial/ethnic groups: black, Hispanic, and white. Multivariable and mixed modeling techniques were used to describe racial/ethnic disparities on tests of memory and mental status (orientation, attention, naming), and to determine if physical activity or education mediated the relationship between race/ethnicity and cognitive function scores. Models were adjusted for demographic, social, and health-related covariates. **RESULTS**: Black and Hispanic adults had lower memory and mental status scores than whites ($p<0.0001$). However, in a subsample of those working for pay, Hispanic adults had no differences in mental status scores from their white counterparts. Leisure-time physical activity and education mediated some relationships between race/ethnicity and cognitive function scores, and were associated with cognitive function scores at each wave. Nevertheless, physical activity, education, and race/ethnicity were not associated with differential rates of change in cognitive function scores. **CONCLUSIONS**: Racial/ethnic differences in cognitive function scores exist in late middle age. Leisure-time physical activity and education partially mediate the relationships; however the covariates used in the analyses were unable to explain all of the differences. Although being white or Hispanic, increased education, increased vigorous activity, and less work-related physical activity were associated with higher memory scores, none differentially impacted rates of change in memory score. Being white and increased education were positively related to mental status scores at each wave. However, no variables of interest were associated with differential rates of mental status score change.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Racial and ethnic differences in health outcomes are at the center of public health discussion in the United States today (U.S. Department of Health and Human Services, 2000; U.S. Congress, 2007). Racial/ethnic disparities exist in nearly every major disease and health condition including infant mortality, cardiovascular disease, diabetes, HIV/AIDS, immunizations, mental health and cognitive function (Albert et al., 1995; Proctor et al., 1997; Kuller et al., 1998; Stump et al., 2001; Zsembik & Peek, 2001; Lopez et al., 2003; Schwartz et al., 2004; National Center for Health Statistics, 2006). Through programs such as Healthy People 2010 and the National Action Agenda to End Disparities for Racial and Ethnic Minority Populations, the U.S. Government has established goals aimed at eliminating these health disparities (U.S. Department of Health and Human Services, 2000; Agency for Healthcare Research and Quality, 2006). In addition, several large professional associations (e.g. the American Medical Association and the American Public Health Association) have made commitments to eliminating health disparities through the work of their members, staff, and affiliated advocacy groups. Furthermore, the National Institutes of Health National Center on Minority Health and Health Disparities was developed in 2000 and provides funding for research agendas that focus on the health needs of racial and ethnic minorities in the U.S. These initiatives demonstrate the growing support by government and the research community for conducting work that documents health disparities and their causes and that identifies interventions that will lessen or eliminate disparities.

In order to respond to calls for research on health disparities in the U.S., the primary purposes of this dissertation are to: (1) document any health disparities that exist in cognitive function and decline, and (2) to present evidence that provides direction for future research on disparities in cognitive function aimed at improving the health of racial/ethnic minorities in the United States.

THE IMPORTANCE OF STUDYING COGNITIVE FUNCTION

Decline in cognitive function has been listed as one of the top fears that adults have about the aging process (Reese et al., 1999; Freidenberg, 2003; Hess, 2006). Compounding fears of decline in cognitive function is the fact that this decline is associated other problems (e.g. increased risk of disability, loss of independence, and premature deaths) (Moritz et al., 1995; Greiner et al., 1996; Leveille et al., 1998; Nguyen et al., 2003). In longitudinal studies, impairment in cognitive function predicts higher numbers of depressive symptoms (Blaum et al, 2002). Cognitive impairment also contributes to mortality risk even in middle age (Pavlik et al., 2003). In addition, due to increases in life expectancy and the growth of the U.S. population, greater numbers of adults have problems with cognitive function that turn into diagnosable diseases such as dementia and Alzheimer's disease. Thus, an increase is expected in the number of adults needing home health care and assisted living or nursing home arrangements. These issues are of concern because research shows that impairment in cognitive function may disproportionately affect underrepresented/underserved groups in the U.S. such as African Americans ().

Race/Ethnicity and Cognitive Function

A number of researchers have examined the relationship between race/ethnicity and cognitive function in older adults. Specifically, research has shown that older black adults have lower scores on tests of cognitive function than do older white adults (Proctor et al., 1997; Kuller et al., 1998; Zsembik & Peek, 2001; Stump et al., 2001; Lopez et al., 2003; Schwartz et al., 2004). Explanations for ethnic differences in cognitive function tests include inequalities in social factors (e.g. education), cultural, and linguistic bias (Sachs-Ericsson & Blazer, 2005; Jones, 2006). However, several gaps exist in the research on race/ethnicity and cognitive function in late middle age adults. First, there is very little research on disparities in cognitive function in late middle age, with most research focusing on older adults (Albert et al., 1995; Christensen et al., 1996; Yaffe et al., 2001; Zsembik & Peek, 2001; Barnes et al., 2003; Abbott et al., 2004; Lytle et al., 2004; Van Gelder et al., 2004; Weuve et al., 2004). It is important to examine potential health disparities in midlife so that future research and interventions aimed at eliminating any documented disparities can be appropriately targeted to middle aged and older adults.

Second, studies illuminate disparities in cognitive function between black and white older adults, but few have included comparisons to other racial/ethnic groups (Albert et al., 1995; Christensen et al., 1996; Yaffe et al., 2001; Zsembik & Peek, 2001; Barnes et al., 2003; Abbott et al., 2004; Lytle et al., 2004; Van Gelder et al., 2004; Weuve et al., 2004; Rovio et al., 2005). It is important to determine if other minority groups, such as Hispanics, suffer from the same disadvantage so that interventions to eliminate disparities and future research can target appropriate groups.

Third, studies that try to explain disparities in cognitive function test scores have typically attributed much of the difference to education, but have not examined the contribution of physical activity. Physical activity levels significantly influence cognitive function among late middle age and older adults (Christensen et al., 1996), and should be explored further as potential mediators between race/ethnicity and cognitive function.

Furthermore, the studies that have demonstrated that physical activity affects cognitive function and cognitive decline have often been limited to samples that are all white or only one gender (Albert et al., 1995; Laurin et al., 2001; Yaffe et al., 2001; Barnes et al., 2003; Abbott et al., 2004; Weuve et al., 2004; Lytle et al., 2004; Van

Gelder et al., 2004; Rovio, 2005; Simons et al., 2006; Larson et al., 2006). These restricted samples do not permit generalization to other groups.

In summary, only a limited number of longitudinal studies have examined racial/ethnic changes in cognitive function. These studies typically have included only one or two racial/ethnic groups, have been restricted to older adults, and have not assessed the explanatory role of physical activity. This dissertation aims to address these gaps in research. The results of these analyses will help clarify whether disparities in cognitive function can be detected earlier in adult life and how physical activity levels may impact the disparities in functioning and/or rates of decline. Therefore, the research goals were to:

- evaluate the cross-sectional differences in cognitive function among Hispanic, black, and white late middle aged adults,
- determine the effects of education and physical activity on the relationships between race/ethnicity and cognitive function among late middle aged adults, and
- evaluate any differences in cognitive decline among Hispanic, black, and white adults beginning in late middle age.

The Health and Retirement Study (HRS), a nationally representative longitudinal study of late middle age and older adults, was used in the current research. This study began in 1992 and the baseline sample included 12,654 adults aged 51 or older and their spouses (Juster & Suzman, 1995). The survey has been conducted biennially and now includes seven waves. The main purpose of the original study was to carefully examine the health and economic transition from late middle age into the retirement years (Juster & Suzman, 1995). Data were collected about the respondents' family structure, labor force participation, financial status, health outcomes, and health behaviors, among other factors (Juster & Suzman, 1995). For this research, data from waves one through six (1992-2002) were used to address the relationships among race/ethnicity, education, physical activity, and cognitive function in late middle aged adults both cross-sectionally and over time.

SPECIFIC AIMS

The specific aims for the proposed research were intended to address the previously identified gaps in studies of race/ethnicity and cognitive function and physical activity and cognitive function. Three specific aims and representative hypotheses were:

Specific Aim I

Determine if there are differences in cognitive function by race/ethnicity in a representative sample of late middle aged white, black, and Hispanic adults.

Description of Specific Aim I

Based on findings from previous research, it is expected that there will be black-white differences in cognitive function scores among late middle aged white and black adults (Proctor et al., 1997; Kuller et al., 1998; Zsembik & Peek, 2001; Stump et al., 2001; Lopez et al., 2003; Schwartz et al., 2004;). It is also expected that there will be differences in cognitive function scores among late middle aged white and Hispanic adults because of the similar socioeconomic disadvantage experienced by Hispanic and black persons in the U.S. (Orzechowski & Sepielli, 2003).

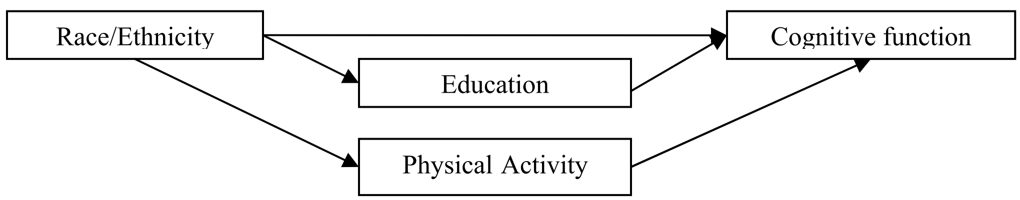
Representative Hypotheses

1a. Black and Hispanic adults will have significantly lower cognitive function scores than white adults.

Specific Aim II

Determine the extent to which education and physical activity mediate the relationship between race/ethnicity and cognitive function in a representative sample of late middle aged white, black, and Hispanic adults (See Figure 1.1).

Figure 1.1 Conceptual relationships among race/ethnicity, education, physical activity, and cognitive function in a multi-ethnic sample of late middle aged adults.



Description of Specific Aim II

In order to explore the potential mediators in the relationships between race/ethnicity and cognitive function found in research previously mentioned, this project will build upon past research by determining the racial/ethnic differences in the relationship between education and cognitive function in a representative sample of white, black, and Hispanic late middle aged adults. Furthermore, because a main purpose of this research is to explore the mediating effects of physical activity on cognitive function, physical activity will be investigated as a mediator between race/ethnicity and cognitive test scores.

Studies that attempt to explain differences in cognitive function by race find that socioeconomic status, particularly education, explains a large part of the variance in the relationships (Brandt et al., 1993; Carlson et al., 1999; Sachs-Ericsson & Blazer, 2005). Because physical activity has been linked to education level, and because education level is such an important predictor of cognitive function and partial mediator of the race/ethnic-cognitive function relationship, it is important to include education in any study about race/ethnicity and cognitive function.

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).

In the present study, physical activity is investigated as a mediator between race/ethnicity and cognitive function partly because of the positive relationship of leisure-time physical activity to education. However, HRS measures of both leisure-time physical activity and work-related physical activity will more adequately assess a participants' physical activity profile. Therefore, accounting for all of those activities may clarify the relationship between race/ethnicity and cognitive function.

Representative Hypotheses

2a. Education mediates the relationship between race/ethnicity and cognitive function in late middle aged white, black, and Hispanic adults.

2b. Physical activity mediates the relationship between race/ethnicity and cognitive function in late middle aged white, black, and Hispanic adults.

Specific Aim III

Explore the relationships among race/ethnicity, education, physical activity, and cognitive function over time in a representative sample of white, black and Hispanic adults beginning in late middle age.

Description of Specific Aim III

There has been limited research regarding how rates of cognitive decline vary by race and ethnicity. Using the Duke Established Population for Epidemiologic Study of the Elderly (EPESE), researchers found that older black adults had significantly greater rates of cognitive decline than older white adults even when controlling for education (Sachs-Ericsson & Blazer, 2005.) In contrast, researchers using the Women's Health and Aging Study, and the Cardiovascular Health Study found no racial/ethnic differences in rates of cognitive decline (Kuller et al., 1998; Atkinson et al., 2005). Previous research from the Asset and Health Dynamics of the Oldest Old (AHEAD) study of adults aged 70 and older suggests that black & Hispanic adults do not decline at a faster rate than white adults, and that black adults may decline at a slower rate (Sloan & Wang, 2005). Conflicting results about race/ethnicity and cognitive function also extend to the mediating role of education.

Education has been shown to be differentially related to cognitive decline (Farmer et al., 1995; Lykestos et al., 1999; Alley et al., 2007). In some cases it is protective of decline (Farmer et al., 1995; Reyes-Ortiz et al., 2005; Sachs-Ericsson & Blazer, 2005; Seeman et al., 2005), but other studies have produced mixed results (Farmer et al., 1995; Alley et al., 2007).

Furthermore, there are few longitudinal studies that examine the relationship between physical activity and cognitive function in older adults, and only one with a representative sample of both black and white adults (Albert et al., 1995; Laurin, 2001;

Yaffe et al., 2001; Barnes et al., 2003; Larson et al., 2006). The MacArthur Studies of Aging determined that physical activity and education were correlates of cognitive decline in both black and white older adults (Albert et al., 1995). No studies, however, compare cognitive decline from late middle age among the three racial/ethnic groups with a focus on the role of physical activity, one purpose of Aim III. The conflicting results from longitudinal studies of racial/ethnic differences in cognitive function provide support for further research on this topic.

Representative Hypotheses

3a. Education is protective of cognitive function from late middle age to older age in all racial/ethnic groups.

3b. Physical activity is protective of cognitive function from late middle age to older age in all racial/ethnic groups.

Additional Specific Aim III Goal

Due to contradictory findings about racial/ethnic differences in rates of decline of scores on tests of cognitive function, a goal of the longitudinal analyses is to explore and report differences or similarities in rates of change in cognitive function scores over time by race/ethnicity after adjusting for demographic, social, and health-related covariates such as education and physical activity.

RESEARCH SIGNIFICANCE

The results from this research will aid in understanding the complicated relationships between race/ethnicity and cognitive function. Documentation of any health disparities in cognitive function in late middle age will support those researching the feasibility of earlier intervention, as well as the development of interventions to increase culturally appropriate physical and mentally stimulating activities in late middle aged adults.

STRUCTURE OF DISSERTATION

The dissertation is presented as follows. Chapters 2 and 3 are introductions to and literature reviews of the key topics of interest: health disparities in late middle aged and older adults, the research definition of cognitive function, racial/ethnic disparities in cognitive function among older adults, and the influence of education and physical activity on cognitive function in late middle and old age. Chapter 4 describes the data and methods used to address the specific aims. The chapter details the study sample and sampling techniques as well as the variables and statistical techniques employed to examine each specific aim. The results chapters (5-7) report the results of the analyses of Specific Aims I, II, and III, respectively. Finally, Chapter 8 includes a discussion and a summary of the results and a description of sensitivity analyses performed to elaborate the main findings. The concluding chapter also includes the author's suggestions regarding how the results can be applied to future research.

Chapter 2: Cognitive Function and Race/Ethnicity

Research about cognitive function in adults is critical to separating speculation about cognitive decline from reality. Many questions remain to be answered: Is cognitive decline unavoidable? What can be done to prevent a decline in cognitive function? Why do scores on tests of cognitive function differ by race/ethnicity? More research is needed to answer questions that continue to perplex researchers. This chapter provides an overview of the definition of cognitive function used in research and a review of the literature relating race/ethnicity and education to cognitive function.

SIGNIFICANCE OF STUDYING COGNITIVE FUNCTION

It has been estimated that some form of cognitive function impairment exists in 9.5% of adults over the age of 70 (Suthers, 2003). That percentage translates into over 2.5 million people in the U.S. (U.S. Census Bureau, 2007). The prevalence of cognitive impairment in old age is similar to that of chronic lower respiratory disease (COPD) and slightly greater than the percentage of adults over 65 who have experienced a stroke (Centers for Disease Control, 2007a; Centers for Disease Control 2007b). Furthermore, impairment in cognitive function has been correlated with several diseases and disorders including depression, stroke, diabetes, hearing and vision conditions, and some musculoskeletal diseases (Blaum et al., 2002). Because cognitive impairment is such a serious health concern, more research on cognitive function is vital to understanding how to preserve function during the aging process.

This chapter includes a description of cognitive function and the different types of medically diagnosable cognitive disorders/diseases. In addition, discussions of research on the relationships among cognitive function, education, and race/ethnicity are provided.

The purpose is to present background information on the significance of the proposed study and how it helps to clarify extant research on cognitive function.

DEFINING COGNITIVE FUNCTION

For the purposes of this research, cognitive function is described as the culmination of several different domains. The various aspects of cognitive function have different labels in research, but generally include memory, attention, praxis (translating an idea into action), language, orientation, reasoning, executive function, and calculation (Roth et al., 1986; Perlmutter, 1988). Cognitive function changes throughout the life course and changes can occur in as few as one or in all domains. Research has shown that cognitive function can be altered by social, behavioral, and health factors (Albert et al., 1995). However, the point at which someone exhibits cognitive function impairment is sometimes difficult to establish (Knopman et al., 2003).

Cognitive Impairment

Cognitive impairment ranges from mild cognitive impairment to dementia. In order to be diagnosed with mild cognitive impairment or dementia, a clinician must be present to examine the patient and have an opportunity to speak to a person who knows the patient in order to extract additional information. In general, several types of cognitive impairment can be detected through clinical diagnosis. First, mild cognitive impairment (MCI) is the clinical state of individuals who are cognitively impaired (typically in their memory) but are otherwise functioning well and do not meet the clinical criteria for dementia (Knopman et al., 2003). The criteria for having MCI include memory complaint, objective memory impairment, normal general cognitive function, intact activities of daily living, and absence of dementia (Knopman et al., 2003). Mild cognitive impairment is a clinically useful concept because it is a strong predictor of dementia and Alzheimer's Disease. In fact, MCI increased the odds of dementia by 12% per year over three years in a study of aging and dementia at the Mayo Clinic (Petersen & Morris, 2003). Furthermore, the same group of researchers followed 66 patients diagnosed with MCI, and transition to Alzheimer's disease occurred at a rate of 12% per year for four years, and 80% were diagnosed by 6 years follow-up (Petersen et al., 1999).

Dementia

A second form of cognitive impairment, dementia, is more serious than mild cognitive impairment and is characterized by impairment that interferes with daily functioning (Knopman et al., 2003; Ropper & Brown, 2005). Symptoms can be observed in memory, speech or language, concentration, and difficulty following instructions (American Psychiatric Association, 2000; Bird, 2001; Johnson et al., 2005). Causes of dementia include Alzheimer's disease (the most common cause), vascular disease, alcoholism, or Parkinson's disease, among other causes (Bird, 2001; Hebert et al., 2003; Johnson et al., 2005).

Alzheimer's Disease

Finally, Alzheimer's disease, which occurs when there is degeneration of the brain, is one of the most severe forms of cognitive impairment (American Psychiatric Association, 2000). Alzheimer's disease is commonly preceded by a period of MCI. Alzheimer's disease symptoms can include forgetfulness and problems with speaking, understanding, reading, and writing (American Psychiatric Association, 2000). In the proposed research, diagnoses of mild cognitive impairment, dementia, or Alzheimer's disease will not be used as specific outcome measures because diagnoses must come from an in-person consultation with a clinician. The participants in the HRS were not assessed by a clinician, rather they were screened using tests designed to assess cognitive function for research purposes.

Cognitive Function in Research

In research, common measures of cognitive function attempt to assess some or all of the different domains. In turn, researchers use the tests, or parts of them, as a proxy measure of the underlying unobservable concept - - cognition (Carmines & Zeller, 1979). For the purposes of the current research, scores on tests that attempt to measure immediate and delayed memory, calculation and attention, orientation, and language will be used as outcome measures. A more detailed discussion of the actual measures is included in the methods chapter. Differences in the scores by race/ethnicity and/or levels of physical activity and education are of interest. The clinical utility of such measures is limited; however, it has been suggested that they can be used to confirm or refute a diagnosis of MCI 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).

RACE/ETHNICITY AND COGNITIVE FUNCTION

This section is a review of studies that have found racial or ethnic disparities in cognitive function or cognitive test scores. With the exception of Stump and colleagues (2001), self-reported race/ethnicity was used, and measures of socioeconomic status were accounted for in multivariable models. In most cases, SES was cited as one reason for the observed differences, but when SES failed to account for the entire difference other explanations were suggested. These additional explanations were reviewed in the section that follows.

Black/African-American and White Disparities in Cognitive Function

Research has consistently shown that older black adults score lower on tests of cognitive function than their white counterparts and suffer from higher rates of cognitive problems such as dementia (Proctor et al., 1997; Kuller et al., 1998; Stump et al., 2001; Zsembik & Peek, 2001; Lopez et al., 2003; Rodgers et al., 2003; Schwartz et al., 2004). The findings have come from some of the major studies on adult health in the United States. For example, findings from the AHEAD study showed that, even when adjusting for SES variables such as years of education, income, and occupation, being black was associated with significantly lower cognitive function scores than being white as measured by mental status using memory questions and questions from the Telephone Interview of Cognitive Status (TICS) (Zsembik & Peek, 2001). The TICS is an examination by telephone that measures the current cognitive status of a participant including memory, orientation, attention, language, and calculation (Brandt, 1988). Later, Rodgers and colleagues combined data from the AHEAD with data from the HRS (2003). They used data from the 1993 wave of the AHEAD and data from the 1998 wave of the HRS and created a single sample of adults over 70 to study. Their goal was to identify trends in cognitive function test scores on tests of memory, calculation, and mental status over time. Results showed that after adjusting for potential confounders such as years of education and educational achievement (diploma/degree), black participants had greater odds of obtaining a low score on the cognitive battery than their white counterparts (Rodgers et al., 2003). Another example of this relationship includes results from the Baltimore Memory Study, a cohort of 1140 men and women between the ages of 50-70. In this study, the results indicated that black participants scored significantly lower than white participants on tests of all cognitive domains in the 90-minute exam even after controlling for socioeconomic status (Schwartz et al., 2004). The exam consisted of a battery of tests that assessed language, reasoning, motor speed, eye-hand coordination, executive abilities (i.e. planning, judgment), and memory. This study is of note because the measures of SES were more complex than level of education and income. The researchers created a SES instrument that accounted for years of education, degrees obtained, wealth, and job duties, among others, a practice that is encouraged by current literature about race/ethnicity and cognitive function (Manly, 2006).

Several additional studies demonstrate similar findings between race/ethnicity and cognitive function in older adults (Proctor et al., 1997; Kuller et al., 1998; Lopez et al., 2003). For example, in a sample of black and white adults over the age of 65 who had been hospitalized for heart disease, participants were screened for possible dementia with the Blessed Dementia Scale Short-Form (Blessed et al., 1968; Proctor et al., 1997). Study participants who had greater cognitive impairment were more likely to be black than white, even when accounting for social class based on self-reported education level and occupation (Proctor et al., 1997). In another study of black and white adults over 65, researchers used the Mini Mental State Examination (MMSE) and the Modified Mini Mental State Examination (3MSE) to determine cognitive function in participants in the Cardiovascular Health Study (CHS) (Kuller et al., 1998). The MMSE is a scale comprised of items that purport to measure domains of cognitive function such as orientation, praxis, attention, and calculation and has a score range of 0-30 with a score of less than or equal to 23 indicating possible cognitive impairment (Folstein et al., 1975). In the CHS, a modified, longer version of the MMSE called the 3MSE was also administered. This scale measured additional domains of cognitive function and has a score range of 0-100 with a score of less than or equal to 80 indicating possible cognitive impairment (Teng & Chui, 1987). Study researchers found that black participants had greater odds (OR=4.1) of scoring less than 80 on the 3MSE than white participants even after adjusting for stroke history (Kuller et al., 1998). After accounting for college education, however, the disparities were not as great.

Cardiovascular Health Study researchers later conducted a cognition study on participants who were classified as having mild cognitive impairment (Lopez et al., 2003). They found that those who identified as African American had four times the odds of being classified as having MCI than those who were white, even when adjusting for education level (Lopez et al., 2003). Moreover, Stump and colleagues (2001) used the Short Portable Mental Status Questionnaire (SPMSQ) that was designed to detect possible cognitive impairment using measures of orientation, memory, and praxis (Pfeiffer, 1975). Scores ranged from 0-10, and categories of scores were listed as intact, mild, moderate, and severe. At baseline, those with mild or moderate to severe impairment were more likely to be black than those with no impairment in cognitive function. Unfortunately, most studies reviewed rarely included multi-racial/ethnic samples. Studies about black/white differences in cognitive function are the most common, but more research is needed to determine if other underrepresented groups suffer the same disparities.

Black/African American, Hispanic, and White Disparities in Cognitive Function

Less information exists on persons of Hispanic ethnicity as compared to other racial/ethnic groups; however, in the AHEAD data, researchers determined that black and Hispanic participants had significantly lower scores on the TICS than white participants, but that the differences between Hispanic/other and white participants were smaller than the differences between white and black participants, after adjusting for education level, net worth, and household income (Sloan & Wang, 2005). Similarly, in the HRS/AHEAD combined study by Rodgers and colleagues that was mentioned previously, Hispanic participants had greater odds than white participants of obtaining a low total cognitive score until education was entered into the model (2003). At that time, the relationship was no longer significant. Another study that included over 2,800 black, white, and Hispanic participants over the age of 40 measured cognitive function and homocysteine (an amino acid that may be damaging to cells that influence cognitive function) (Wright et al., 2004). Cognitive function was assessed in either English or Spanish using the Mini Mental State Exam. At baseline, Hispanic and Black participants had lower MMSE scores than white participants, but the score differences were based on unadjusted statistics (Wright et al., 2004).

Summary - Cross-Sectional Research

In general, cross-sectional research from the last decade has shown that older black adults score lower on tests of cognitive functioning than older white adults and, in a few studies, that older Hispanic adults also score lower on tests of cognitive function than their white counterparts. It is difficult to interpret these findings without knowing if the same relationships exist in longitudinal studies. Does the disparity remain over time, and does the rate of cognitive decline also differ by race/ethnicity? Furthermore, interpreting the findings is also impossible without exploring the possible reasons behind them such as socioeconomic status or health behaviors.

Race/Ethnicity and Cognitive Decline

Some research shows that cognitive decline may occur at different rates for different racial/ethnic groups (Albert et al., 1995; Sachs-Ericsson & Blazer, 2005; Fillenbaum et al., 2001); however, it has also been found that there are no differences by race/ethnicity in cognitive decline (Atkinson et al., 2005). In the discussion that follows, longitudinal studies that examine cognitive decline and potential explanations for the racial/ethnic differences will be explored. A few studies have been performed on cognitive decline in the context of race/ethnicity with contradictory results (Albert et al., 1995; Fillenbaum et al., 2001; Atkinson et al., 2005; Sachs-Ericsson & Blazer, 2005). Three have found that older black adults have greater rates of decline of scores on various tests of cognitive function (Albert et al., 1995; Fillenbaum et al., 2001; Sachs-Ericsson & Blazer, 2005), one found no racial/ethnic difference (Atkinson et al., 2005), and two showed found slower rates of decline for blacks versus whites (Sloan & Wang, 2005; Alley et al., 2007).

Most studies of cognitive decline are conducted with predominantly white samples. However, there are a few exceptions. As mentioned previously, Albert and colleagues found that being black was a predictor of cognitive decline in the MacArthur Studies of Successful Aging (1995). In the Duke EPESE, researchers found that older black adults had significantly greater rates of cognitive decline than whites on the Short Portable Mental Status Questionnaire (Sachs-Ericsson & Blazer, 2005). In a smaller sample of participants from the Duke EPESE, Fillenbaum and colleagues continued to observe the same racial/ethnic difference when accounting for possession of the APOE4 gene (2001). The presence of the APOE4 gene is associated with worse cognitive function outcomes (Fillenbaum et al., 2001). Results from the MacArthur Studies of Successful Aging showed similar findings using a neuropsychological battery of tests that assessed language, memory, reasoning, and visuospatial ability (Albert et al., 1995). Conversely, it is important to note one study conducted showed no significant differences by race/ethnicity in cognitive decline and two have shown that decline for blacks was less than that for whites (Sloan & Wang, 2005; Alley et al., 2007). In the Women's Health and Aging Study, researchers examined 558 women with MMSE scores greater than 24 at baseline and tracked cognitive decline over the course of three years (Atkinson et al., 2005). Researchers found no differences by race/ethnicity in cognitive decline, as defined by a decrease in MMSE score to less than 24 (Atkinson et al., 2005). Using the AHEAD data, Sloan & Wang determined that black adults had slight gains in scores on mental status measures as compared to whites (2005). More recently, Alley and colleagues used the AHEAD study to examine differences in memory and mental status using different analyses (2007). Black adults had slower rates of decline on memory measures compared to white adults, and Hispanic persons had faster rates of decline on mental status items compared to white adults (Alley et al. 2007). With so few studies that have a focus on race/ethnicity and comparing rates of cognitive decline and at least one contradictory result, further research that examines the connection between race/ethnicity and cognitive decline should be explored.

Additional Nonsignificant Results

There are a few studies to date that were unable to detect differences by race/ethnicity in cognitive function. Carlson (1998) assessed 72 Alzheimer's disease patients' scores on the MMSE, and tests of memory, praxis, attention, verbal skills, and language that composed a neuropsychological battery with a total of 13 components. Black and white adults showed no significant differences in 10 of the 13 components (Carlson, 1998). Likewise, in a study of over 17,000 decedents, Yoder and colleagues interviewed the next of kin over the age of 15 about the decedents' cognitive status, specifically, their relatives' difficulty understanding, remembering, and recognizing, in the last year of life (2001). In multivariable models, race/ethnicity was not a predictor of difficulty in any areas of cognitive function. These studies are of note, but it is important to point out that one was conducted in patients already diagnosed with Alzheimer's disease, and the other used proxy respondents only to answer questions that were not typical to those found in scales of cognitive function most commonly used in the literature.

EXPLANATIONS FOR RACIAL/ETHNIC AND COGNITIVE FUNCTION DISPARITIES

A number of explanations for racial/ethnic disparities in cognitive function have been provided by researchers. It is generally accepted that the differences are not due to the genetic classification of "race," rather they are due to social factors such as education (Manly, 2006). In the event when racial/ethnic differences can not be attributed to social factors alone, researchers turn to concepts that may have interfered with results such as unmeasured cultural differences, perceived racism, inadequate measurement of socioeconomic status, and quality and potential racial/ethnic biases of the measures that purport to describe cognitive function in adults (Fillenbaum et al., 1990; Whitfield et al., 2000; Zsembik & Peek, 2001; Manly, 2006). Many of these explanations are examined in detail in the discussion section, but education and measurement quality are briefly described here.

Measurement Quality

In recent years, some researchers have challenged results commonly found in the literature regarding the racial/ethnic differences in scores on tests of cognitive function by pointing out racial/ethnic biases in measurement (Fillenbaum et al., 1990; Jones, 2006; Ramirez et al., 2006). The argument is that cognitive tests can produce different results in different racial/ethnic groups due to a variety of factors such as language, education, or cultural differences. In addition, when the tests appear to produce the same overall scores, the responses to the underlying measures may not be equivalent across racia/ethnic groups. This lack of measurement invariance (the absence of measurement bias) is commonly referred to as Differential Item Functioning (Teresi, 2006).

Test Bias - Differential Item Functioning

In 1995, Teresi and colleagues evaluated racial/ethnic and educational bias on over 50 single items on tests of cognitive function. They found that black, Hispanic, and white participants scored differentially on questions on cognitive function tests such as naming your street address, recalling your telephone number, recalling the date of WWI, spelling one's name, and repeating the statement, "no ifs, ands, or buts," indicating racial/ethnic item bias (Teresi et al., 1995). However, with the exception of "no ifs, ands, or buts," they did not provide thorough justification as to why certain groups may perform differentially on certain items. In the case of "no ifs, ands, or buts," the authors suggested that the Spanish translation may have been easier to repeat than the English version and therefore Spanish-speaking participants were more likely than other participants to correctly respond.

Several additional studies have examined these issues. In 2000, researchers reanalyzed data from the MacArthur Studies of Successful Aging to take a closer look at some of the differences on cognitive function tests between white and black participants (Whitfield et al., 2000). Subjects participated in a test of naming objects presented in pictures as well as a recall test for memory. In initial analyses, black participants had lower average scores than white participants on both the naming and recall tests. Upon further examination, the researchers speculated that the naming test may be culturally biased. Reasons for this include the potential for regional and/or ethnic variation in names for items. For example, the authors suggested that in southern states (from which a higher proportion of black participants lived), the word swing may be used for the picture of a hammock (Whitfield et al., 2000). In the current research, naming tests were used as part of a mental status outcome measure. Description of these tests and attempts to establish their appropriateness for the sample are presented in Chapters 4 and 5.

More recently, in a special supplement of *Medical Care*, several groups of researchers used a variety of procedures to detect differential item functioning on the MMSE, one of the most widely used tests of cognitive functioning in research (Crane et al., 2006; Dorans & Kulick, 2006; Edelen et al., 2006; Jones, 2006; Ramirez et al., 2006). In a review of the literature, Ramirez and colleagues found that there was evidence for differential item functioning due to factors related to ethnicity on 10 of 21 items (2006). These items included, but are not limited to, season, date, state, repeating words, and following directions. After the analyses, though most of the items were also associated with low levels of education, several additional reasons for the differences were provided including native language differences, low acculturation levels, and geographical variants (Crane et al., 2006; Dorans & Kulick, 2006; Jones, 2006). However, Edelen and colleagues reported that because the direction of the differentials were not the same for every item, the overall scores were not affected (2006). Differing conclusions about the items in the MMSE found by the different groups make it difficult to determine the overall meaning of the findings, but it is clear that it is important to examine potential bias in research tools such as the MMSE.

Other Evidence of Test Bias

In addition to the studies already mentioned, Fillenbaum and colleagues used a sample of black and white adults diagnosed with dementia from the Duke EPESE to demonstrate that several cognitive tests like the MMSE showed much lower specificity (ability to exclude presence of cognitive impairment) in the black participants than in the white participants in the sample (Fillenbaum et al., 1990). They noted that shorter, less complex screening tools tended to be more reliable for both white and black adults than those that were particularly long or difficult. Furthermore, it has been suggested that memory tests are one of the few appropriate measures for multi-ethnic samples (Manly, 2006). In addition to racial bias for black adults, it is uncommon for cognitive screening tools to be validated in Hispanic participants. Native language, length of time in the United States, lower education, and poverty, all associated with Hispanic ethnicity, have effects on scores on tests of cognitive function (Gasquoine, 2001).

There are several ways to address measurement bias prior to research. In order to correct for an over diagnosis of cognitive impairment in African American groups, using different cut off scores for people of different races/ethnicities has been proposed (Mouton, 1997). This approach has been debated. One concern is that race/ethnicity often serves as a proxy for other variables of interest such as education. At present, there is no scientific basis to date for different norms for African Americans and whites (Manly et al., 2005; Manly, 2006). Another way to address bias is to thoroughly examine cognitive measures for bias prior to analysis through techniques such as confirmatory factor analysis, or guided by Item Response Theory (Bowden et al., 2004; Edelen et al., 2006).

Health and Retirement Study researchers are aware of the potential for problems in measurement quality across racial/ethnic groups (Ofstedal et al., 2005). They have not tested the measures for invariance; however, they suggest that there are no substantial differences in internal consistency between races/ethnicities on the major cognitive function scores that are indicative of poor measurement quality (Ofstedal et al., 2005). Also, researchers have been able to demonstrate that expected correlates of cognitive function are consistent across racial/ethnic groups (Ofstedal et al., 2005). On the contrary, an earlier article that assessed racial bias in both the HRS and the AHEAD, pointed out that certain items in the cognitive battery such as the serial seven subtraction item and the naming of the president and vice president of the United States showed very high discrepancies by race/ethnicity and that much of the differences can be attributed to background variables such as education (Jones, 2003). To address this in the current study, education was accounted for in statistical models. In addition, a mental status summary score created by the HRS researchers that excludes the serial seven subtraction item was used.

Racial/ethnic bias was further addressed prior to analyses. First, reliability of the measurements was examined within each racial/ethnic group. Second, it was confirmed that the major correlates of cognitive function (e.g. education and depressive symptoms) were correlated in the same direction for each racial/ethnic group. However, measurement validity was not established. The results of these analyses and their limitations are presented in the results chapters. Aside from measurement quality, one of the most cited explanations for differences in cognitive function is education.

Education

Education is highly correlated with cognitive function, and there are several hypotheses related to this relationship. A primary hypothesis is that since there are racial/ethnic disparities in education, racial/ethnic disparities in cognitive function are related. This may occur due to several reasons. First, education may lead to a longer latent period (a period of time without clinical symptoms) of cognitive decline by directly affecting the brain's structure during early developmental years. This is also referred to as a "cognitive reserve" (Stern et al., 1999). Evidence for this hypothesis has been shown in some rat models (Greenough, 1985). Second, education contributes to the development of skills that support the thinking and mental strategies (Mirowsky & Ross, 2003) that may be required for certain kinds of cognitive tests (Albert, 1995). Finally, low levels of education may be accompanied by poorer health behaviors and illnesses that can affect cognitive function over time (Albert, 1995).

Researchers have not reached a consensus on all of the proposed hypotheses, but it is commonly agreed that education does affect cognitive function. For example, in a study of patients with Alzheimer's disease, Carlson proposed that at least 20% of the differences in cognitive function by race/ethnicity were due to education (1998). A similar estimate found from a study of 4000 male twin pairs also suggested that approximately 20% of the variance in the relationship between race/ethnicity and cognitive function was due to education (Brandt et al., 1993). In the current study, education was examined as a predictor of cognitive decline and a mediator between race/ethnicity and cognitive function. Although a wealth of research has been dedicated to these relationships, sufficient attention to education is necessary in any study of cognitive function because of the consistent nature of the association. One important question remains, however: what accounts for the remainder of the variance? If health behaviors that may affect cognitive function have been described as potential explanations (Albert, 1995), it is possible that physical activity is responsible for an additional portion of the variance in the relationship between race/ethnicity and cognition. This idea is explored in the following chapter.

Researchers have demonstrated that measurement quality and education may be primary reasons that we see lower cognitive function scores among minority older adults. Because of the associations previously described between education and health behaviors, an exploration of the potential of physical activity to be a factor in the race/ethnicity-cognitive function relationship was conducted.

Chapter Summary

In the U.S. today, 4.5 million adults have Alzheimer's Disease (Hebert et al., 2003). It is important to study cognitive function in adults as they age to help us understand the ways in which we can prevent impairment in cognitive function and cognitive diseases. The purpose of Chapter 2 was to provide background information on how the present research will help to enrich what we know about cognitive function in late middle age. Research from the past 10 years has shown that older black and Hispanic adults score lower on tests of cognitive function than their white counterparts. In addition, some research shows that rates of decline by race/ethnicity may differ, with minorities experiencing more rapid declines. However, there are conflicting results regarding race/ethnicity and cognitive decline.

Some common explanations for differences by race/ethnicity in scores on tests of cognitive function are educational disparities and quality and cultural bias of cognitive tests, but there are other possibilities to consider. In the following chapter, physical activity will be reviewed as a predictor of cognitive function and maintenance of cognitive function over time. Furthermore, physical activity may be an important mediator in the relationship between race/ethnicity and cognitive function. This possibility will also be explored in the coming chapter.

Chapter 3: Physical Activity and Cognitive Function

There are a number of lifestyle and socioeconomic factors that researchers hypothesize influence cognition or scores on tests of cognitive function. As previously mentioned, education is purported to be one of the strongest predictors of performance on tests of cognitive function. Due to racial/ethnic differences in education, it is possible that there are other predictors of cognitive function that differ by race/ethnicity that partially explain the racial/ethnic disparities in cognitive function. One example is physical activity. Rarely, if ever, do studies of race/ethnicity and cognitive function examine a physical activity as an additional factor. An exception to this was Albert and colleagues in 1995, who noted that, although it was not the focus of their study, strenuous physical activity may have mediated the effect of race/ethnicity on cognitive function. The potential differences by race/ethnicity in physical activity and the strong relationship between physical activity and cognitive function warrant closer examination.

RACE/ETHNICITY AND PHYSICAL ACTIVITY

In the past two decades, national-level research studies have presented findings that non-white adults are less likely to engage in leisure time physical activity than their white counterparts (Crespo et al., 1996; Centers for Disease Control, 2005). Survey results from the 9500 adults in the third National Health and Nutrition Examination Survey (NHANES) also showed that the prevalence of no leisure-time physical activity (LTPA) was greater in Mexican American men and women and black women than other races/ethnicities (Crespo et al., 1996). Using more recent data from the Behavior Risk Factor Surveillance System (BRFSS) between 1994 and 2004, researchers showed that white men and women had lower prevalences of no LTPA than their Hispanic and black counterparts (Centers for Disease Control, 2005). Over time, inactivity decreased in all groups, but the discrepancies by race/ethnicity remained (Centers for Disease Control, 2005). Following the reports of data such as these, researchers began to search for explanations that may help understand the relationship between race/ethnicity and physical inactivity. One possible explanation lies in differences in education.

Education has been suspected as a confounder of the relationship between race/ethnicity and physical activity (Crespo et al., 2000). In both men and women who are white, black, or Mexican-American, greater years of education lead to lower levels of physical inactivity (Crespo et al., 1999). Because black and Mexican-American persons have fewer years of education than their white counterparts, education may confound the relationship between race/ethnicity and physical activity (Crespo et al., 2000). However, this association is not simple. Education does not explain the differences by race/ethnicity in LTPA when grade levels are less than 12 years in both male and female black and Mexican American adults. Additionally, among black and Mexican American females, levels of leisure time inactivity are greater then levels for whites for all education groups (Crespo et al., 2000). Furthermore, physical activity does not just occur during leisure time.

Another explanation for perceived differences in physical activity by race/ethnicity could be due to the failure of many health surveys to include measures of work-related physical activity. In the Health and Retirement Study, researchers have found that black and Hispanic persons were much more likely than their white counterparts to participate in work-related physical activity (He & Baker, 2005). This finding provides support that when accounting for physical activity in a comprehensive way, the differences between racial/ethnic groups' cognitive function scores may diminish. These studies suggest that in many cases, black and Hispanic adults are less likely to engage in leisure time physical activity than white adults, but that the relationship between race/ethnicity and physical activity is not completely clear.

RACE/ETHNICITY, PHYSICAL ACTIVITY, AND COGNITIVE FUNCTION

It is possible that part of the variance in the relationship between race/ethnicity and cognitive function is due to differences in levels of physical activity or differences in types of physical activity. A number of observational and experimental biological studies provide evidence for how physical activity potentially influences cognitive function.

Biological and Animal Models

As explained previously, impairment in memory is often one of the first signs that there are potential problems with cognitive function (Knopman et al., 2003). The part of the brain responsible for memory is the hippocampus in the temporal lobe (Fuster, 2000). Because of this, most animal studies that focus on exercise and cognitive function limit the study area to this region of the brain (Kramer et al., 1999). Several of these studies have been performed on older animals.

In 2005, van Praag and colleagues studied older mice to determine the effect of exercise (regular running on a wheel during the previous 1.5 months) on the performance in the Morris water maze (Morris, 1984). The maze was developed and tested for use with rodents as a way of observing their learning and memory abilities (Morris, 1984). The researchers found that the mice who had been exercising were more likely to master and remember the way to the platform at the end of the maze than their matched counterparts. In addition, those who exercised had more neuron growth than the controls (van Praag et al., 2005). This growth was located in an area of the hippocampus known to affect memory called the dentate gyrus. Even more recently, Albeck, and colleagues demonstrated similar results after treadmill exercise with rats (Albeck et al., 2006).

As recently as March 2007, researchers used advanced brain imaging (MRI) techniques to determine if exercise would increase the cerebral blood volume in mice in the dentate gyrus (Pereira et al., 2007). Researchers first tested their methods in mice which ran on wheels during a two week period. The MRIs were performed at 0, 2, 4, and 6 weeks. Then, 11 humans who had below average fitness levels were enrolled in exercise training for 12 weeks. MRI images were compared over time to determine the effects of the exercise. The study results showed that in the mice, as well as the humans, increased cerebral blood flow in the dentate gyrus showed up on the MRIs post exercise. In addition, the human subjects' cerebral blood flow changes correlated with their performance over time on a test of memory (Pereira et al., 2007). This is some of the most compelling research to date that directly links exercise with improved brain function or plasticity. However, many observational studies exist that exhibit supportive results.

Experimental and Observational Studies

Several cross-sectional and longitudinal studies have demonstrated a relationship between physical activity and cognitive function even in late middle age. For example, in a cross-sectional study of 664 participants over 70, both self-reported and informant-reported levels of physical activity were positively associated with MMSE scores even when controlling for other model variables (Christensen et al., 1996). In addition, two studies have shown the relationship as an acute effect (Molloy et al., 1988; Emery et al., 2001). Most recently, 29 participants who were diagnosed with chronic obstructive pulmonary disease were enrolled and matched (by age, sex, and education) to 29 healthy controls (Emery et al., 2001). The subjects participated in a bicycle stress test for 20 minutes and they also watched 25 minutes worth of education videos about the benefits of exercise. Before and after each task, they completed pre and post-cognitive battery tests. The battery included tests of memory, processing, and motor speed, among others.

Following the exercise, study participants had higher scores on the verbal tests than those who did not exercise. This indicated that acutely, exercise may impact verbal processing (Emery et al., 2001). A similar study of fit older adults and controls found that after 45 minutes of exercise, the experimental group had significantly greater scores on the MMSE and a memory test than controls (Molloy et al., 1988).

Longitudinal studies with similar relationships have also been present in the literature. Researchers using the MacArthur Study of Successful Aging showed that participants with higher levels of strenuous activity had smaller declines on the cognitive battery over the next two years than those with lower levels (Albert et al., 1995). Moreover, Barnes and colleagues showed that as levels of oxygen consumption during exercise and oxygen uptake efficiency (both indicators of physical activity) increased, MMSE scores remained higher than in those with lower oxygen consumption after a six year follow-up (2004). In this study, participants had no indication of cognitive impairment at baseline as measured by a variety of cognitive tests.

Additionally, in a 6-8 year study of almost 6000 women over the age of 65 in the Study of Osteoporotic Factors, participants with no cognitive impairment at baseline as measured by the modified MMSE, were followed (Yaffe, 2001). Those who had higher levels of baseline physical activity were significantly less likely to show decline in cognitive function over time than those who had lower levels (Yaffe, 2001). Another study of women, the Nurses' Health Study, provided evidence that those who had the greatest levels of weekly energy expenditure had a 20% risk reduction in cognitive decline than those who had the lowest level of activity (Weuve et al., 2004). Also in 2004, Lytle and colleagues tested cognitive decline with the use of the MMSE in over 1500 adults over 65 years old. Decline was defined as a decrease in score of 3 or more points after approximately four years. Those who participated who did not exercise had

1.61 greater odds of having cognitive decline than those who exercised three times a week or more (Lytle et al., 2004). And, finally, in a small study of approximately 300 men born between 1900 and 1920, those who exercised the least had approximately double the odds of a decline in scores on the MMSE after 10 years than those whose exercise levels were in a higher quartile (van Gelder et al., 2004).

There have also been studies to show significant effects of physical activity on diagnosed cognitive illnesses. Abbott and colleagues studied the onset of dementia in over 2200 men as part of the Honolulu-Asia Aging Study and found that men who walked less than two miles per day had a higher risk of dementia than those who walked two miles or more per day. A study of the participants in the Cardiovascular Risk Factors, Aging, and Incidence of Dementia Study (CAIDE) also yielded positive results. Middle aged participants who engaged in leisure time physical activity (that caused heavy breathing and sweating) at least twice per week for at least 20 minutes had a decreased risk of dementia and Alzheimer's disease than those who did not (Rovio et al., 2005). Moreover, participants in the Dubbo Study of the Elderly in Australia were less likely to develop dementia if they participated in gardening activities (Simons et al., 2006). In a recent community-based paper, Larson and colleagues showed an association between increased physical activity and less diagnosed dementia and Alzheimer's disease in a group of individuals over the age of 65 who were part of the Adult Changes in Thought cohort (2006). Finally, in a six month experiment, 124 sedentary adults over the age of 60 were assigned to aerobic exercise (walking) or anaerobic exercise (stretching) (Kramer et al., 1999). Pre and post-exercise cognitive tests showed that on cognitive tasks that involved the prefrontal and frontal cortex (areas of the brain particularly sensitive to exercise), and those who engaged in aerobic exercise performed significantly better on post-tests than those who did not (Kramer et al., 1999).

The research reviewed showed that there is an overwhelming amount of evidence that physical activity is beneficial to cognitive function, brain plasticity, and possibly the delay of cognitive diseases, even in late middle age. Though the studies demonstrating the relationship between physical activity and cognitive decline abound, they rarely include a race/ethnic component. Survey participants in published research are often all one racial/ethnic group or all one gender (Albert et al., 1995; Laurin, 2001; Yaffe et al., 2001; Barnes et al., 2003; Abbott et al., 2004; Lytle et al., 2004; van Gelder et al., 2004; Weuve et al., 2004; Rovio, 2005; Larson et al., 2006; Simons et al., 2006). The proposed research offers an opportunity to enhance existing knowledge about physical activity and cognitive function by extending the research with a socio-demographic component.

Nonsignificant Results

Other inconsistencies in previous research include some negative findings about physical activity and cognitive function. For example, in a community study conducted near Chicago, researchers found no effect of physical activity on cognitive decline (as measured by a global score summing the results from recall tests, the MMSE, and a test of motor ability) when accounting for cognitive activities such as reading (Sturman et al., 2005). Limitations, however, included the lack of a Hispanic comparison group and also the lack of a work-related physical activity measure (Sturman et al., 2005). These limitations can also be addressed in the proposed research. In addition, none of the nonsignificant findings were from experimental studies, and most of the studies reviewed relied on reports of leisure time physical activity. This does not allow for differential results by type of activity - a component critical to the translation of this kind of research into practice. If activity of all kinds is related to better cognitive function, then that is useful information for health care professionals. However, it is possible that only certain kinds of activities are relevant or protective. Again, the present research can begin to address this issue with the use of several different types of physical activity. The following chapter is a presentation of the methods used to carry out the proposed research including a description of the study design, sample, variables and analytical methods.

CHAPTER SUMMARY

When Albert and colleagues demonstrated that strenuous physical activity may mediate the effect of race/ethnicity on cognitive function in a large sample of older adults (1995), they provided strong evidence that an additional explanation for the racial/ethnic disparities in cognitive function existed. The purpose of Chapter 3 was to review the differences in physical activity by race/ethnicity and the evidence that physical activity is protective of cognitive function. Overall, research suggests that non-white adults are less likely to engage in leisure time physical activity than white adults. However, it is not an accurate picture of a person's physical activity profile when work-related activity is not taken into account. In addition, many studies, both observational and experimental, have shown that physical activity is protective of cognitive function. The studies lead to obvious questions: What kinds of physical activity are most protective of cognition? If work and leisure time physical activities are taken into account, do they mediate the relationship between race/ethnicity and cognitive function? One purpose of the present research, therefore, is to examine the contribution of physical activity to cognitive function in the context of race/ethnicity. These analyses will provide information regarding modifiable health behaviors that may influence cognition and will attempt to explain some of the variance in the relationship between race/ethnicity and cognitive function.

Chapter 4: Methods

INTRODUCTION

This chapter presents information about the study population, study design, variables, and research methods employed to address the specific aims. These details include a description of the HRS and the participants enrolled as well as a description about the variables in the HRS that were chosen for the current research. In addition, explanations of the analytical techniques used to evaluate the relationship between race/ethnicity and cognitive function in the sample (Aim 1), whether physical activity or education mediates that relationship (Aim 2), and whether similar relationships exist between the variables across time (Aim 3) are provided.

STUDY POPULATION

The data set used for this research is from the Health and Retirement Study (HRS). The National Institute of Aging has funded the HRS continuously since 1991. Data collection began in 1992 with a multistage area probability sample of US adults and their household members aged 51 and older that included oversamples of Florida residents and black and Hispanic participants (n=12,654) (Juster & Suzman, 1995). To provide researchers with an overview of aging in America from late middle age and on, respondents were asked about their health status, insurance coverage, financial status, family systems, work status, and retirement plans. The study is longitudinal and respondents are surveyed every two years to record changes in their health, financial status, and social variables in order for researchers to determine predictors of a variety of common health and/or retirement outcomes (Juster & Suzman, 1995). To select the sample, the following stages were employed (Heeringa & Connor, 1995). Stage one created 61 primary sampling units (PSUs) using probability proportionate to size selection of Metropolitan Statistical Areas (MSAs) (Spotila, 2000) and non-MSAs in the United Sates. These 61 PSUs were chosen to ensure an over sampling of black and Hispanic adults, as well as residents of the state of Florida. In stage 2, second-stage sampling units (SSUs) were created from US Census block data. The numbers of SSUs within each PSU were based on the population size of the primary sampling unit. In stage three, an equal probability sample of housing units (HUs) was selected from each second-stage sampling unit. Finally, in stage 4, a housing unit was considered eligible if there was a person living there who was born between the years of 1931 and 1941. Out of 15,497 eligible respondents, 12,987 were contacted, and 12,654 participants were interviewed indicating a baseline response rate of 82 percent. Response rates in future waves for only those who were interviewed at Wave I were 92%[1] (n=11,929) at Wave II in 1994, 87% (n=11,316) at Wave III in 1996, 84% (n=10,866) at Wave IV in 1998, 80% (n=10,325) at Wave V in 2000, and 77% (n=10,048) at Wave VI in 2002. Losses to follow up included those who died, refused, or were unable to be interviewed for other reasons (see Table 4.1).

Table 4.1. Sample Attrition in the Health and Retirement Study from 1992-2002.

	Interviewed (full or partial)	Refusal (by self, spouse, or representative)	Not Interviewed (no contact, lost interview, too sick, etc)	Other reason (e.g., requested removal)	Deceased before interview	Formally dropped from sample (completed exit interview (deceased), could not find proxy, dropped from previous wave, etc.)
1992	12654		333			
1994	11929	713	273	21	51	
1996	11316	1063	318	8	48	234
1998	10866	948	496	1	31	645
2000	10325	1085	356	154	55	1012
2002	10048	1043	157	157	67	1515

Notes: Eligible participants numbered 15,497 at baseline. Contact was made with 12,987 respondents at Wave I.

[1] The denominator used for calculating the response rate was the number of respondents contacted (12,987) at time 1 (1992).

Study Sample Size

HRS researchers created a tracker file to help users organize the data for longitudinal analysis. The number of respondents that were linked with the HRS-created longitudinal tracker file was 12,652 (Health and Retirement Study, 2007). In addition, several modifications were made to the sample to prepare it for the analyses. Participants were excluded if they were younger than age 51 or older than age 61 at baseline, responded by proxy, and/or they reported a race/ethnicity other than white, black, or Hispanic.

At Wave I, respondents who were not between the ages of 51 and 61 were excluded from the sample because the focus of the current research is late middle aged adults. Participants were further categorized into those who responded by proxy and those who did not. Proxy-responding participants (~5%) are also excluded from the study primarily because those who interviewed by proxy have no responses to variables, such as depressive symptoms or cognitive function outcome measures, relevant to the proposed study. In addition, other participants that are excluded are those who had incomplete data on the racial/ethnic measures or reported that they were "American Indian," "Alaska Native," "Asian," "Pacific Islander," or "Other" who did not identify as Hispanic or Latino. These exclusions brought the sample size for the study to 9,204 at baseline. The same exclusions were employed for Waves II-VI (see Figure 4.1). The sample size modifications were addressed in multivariable modeling through the use of propensity scores and HRS sample weights. In other words, the probability of a participant being selected for the final reduced sample was accounted for in the models. This is explained further in the next section.

Figure 4.1. Sample sizes used to study the relationships among race/ethnicity, education, physical activity, and cognitive function in a sample of late middle age and older adults from the Health and Retirement Study (1992-2002).

	Wave I 1992	Wave II 1994	Wave III 1996	Wave IV 1998	Wave V 2000	Wave VI 2002
Eligible	15,497					
Interviewed	12,652	11,929	11,316	10,866	10,325	10,078
Age 51-61 at Wave I	9,892	9,065	8,458	8,046	7,568	7,270
Non Proxy	9,407	8,689	8,103	7,707	7,243	6,964
Race/ethnicity = Hispanic, white, black	9,204	8,509	7,944	7,556	7,902	6,826

Data Weighting

In order to eliminate selection bias, a 3-step weighting process was used. First, HRS-created weights were applied to the sample used in the analysis. Second, each participant was assigned a propensity score and subsequently a participation rate category based on the sample restrictions placed on the data set (e.g. non-proxy, racial/ethnic). Finally, the HRS weights and the participation rates were multiplied to create weights appropriate for the sample used in the analyses. Similar procedures have been used in other research based on the HRS/AHEAD samples (Wolinsky et al., 2007).

HRS Weights

In order to account for the over sampling of three distinct subgroups (residents of Florida, black, and Hispanic participants) post-stratification, sampling weights were created for HRS Wave I data at both the household and individual levels. All households have a selection weight of 1 except for those who were included in one of the over sampled subgroups. Those households had double the chance of being included in the sample and therefore were assigned a sampling weight of 0.5. Those who were a part of more than one sampling domain, (i.e. a black household in Florida) were assigned a weight of 0.25. Once households were selected, the age-eligible respondents in each household were interviewed. Person-level sampling weights were then created to address a different set of unique sampling issues.

Five types of sampling weights were created for the different types of age-eligible respondents in households. They were for households that had 1) one single respondent, 2) two single respondents, 3) two age-eligible married persons, 4) two married persons with one age-eligible, and 5) two age-eligible married persons and one age eligible single person. Each sampling weight was based on the probability of selection and weights ranged from 1-4.

Propensity Scoring

Using the HRS weights as they were created is not entirely appropriate when the sample size has been reduced as in the current study. Because there were racial/ethnic and proxy restrictions on the data, the weights needed to be recalculated to reflect those restrictions. This adjustment was done through the use of propensity scoring. The original HRS weights reflected the chance of being in the HRS sample. The propensity score is the conditional probability of making it into the reduced sample for the present analysis given the covariates used (Rosenbaum & Rubin, 1983).

In order to create the propensity score, a logistic regression predicting whether or not a participant made it into the study sample given all of the baseline independent covariates was performed. The output result is a probability of being included in the sample. In these analyses, the propensity scores were arranged into quintiles with the highest quintile containing the people with the greatest chance of being included in the sample given the restrictions and the model covariates. The lowest quintile contained the people who were most unlikely to get into the sample. From that information, the participation rate was extracted. A participation rate is simply the percentage of people who were in each quintile. The HRS weight for each participant was multiplied by the inverse of the participation rate for that person. This created a new weight that was adjusted for the sample size restrictions. Weights were applied in all cross sectional analyses. Sensitivity analyses without survey weights were performed and the results can be found in the discussion section.

Strengths of the HRS Data

The HRS has several strengths that made it an appropriate dataset for the current project. First, the HRS sample used in the analyses contains a substantial number of minority respondents including 869 Hispanic and 1,609 black adults at Wave I. As mentioned previously, most longitudinal reports of cognitive decline and physical activity are limited to adult samples that are not multi-ethnic or include only one gender. Second, strenuous physical activity is a strong predictor of cognitive decline (Albert et al., 1995) and the HRS includes several variables that assess physical activity. The HRS includes questions about work-related physical activity in addition to asking respondents about vigorous leisure time physical activity or exercise. It is not common to find measures of physical activity in surveys that include activity at work. This shortcoming in other datasets prevents researchers from estimating a comprehensive physical activity profile. Third, the HRS includes multiple measures of cognitive function that cover a wide variety of cognitive abilities identified by psychologists, gerontologists, geriatricians, and psychiatrists (Ofstedal et al., 2005). Finally, research on potential disparities in cognitive function in middle age or late middle age is sparse. With a younger sample like that of the HRS, the possibility that disparities occur prior to old age may be investigated.

Limitations of the HRS Data

Measurement uniformity and missing data are the two main limitations of the data provided by the survey. Limitations of the study were reviewed in the discussion chapter.

Measurement Uniformity

As in many longitudinal studies, the measurement of variables is not consistent in every wave of the HRS. This limitation posed a few problems for the analyses. The most comprehensive measures of physical activity are included only in Wave I (see Table 4.2) and there are few physical activity measures from Waves II and beyond. Furthermore, the HRS did not include any biometric measures to assess physical or cardiorespiratory fitness. Therefore, the results of this study should be validated with a study that provides more rigorous measures of physical fitness. Conversely, in Waves I and II, the measures of cognitive function are fewer in number and less comprehensive than in Waves III-VI (see Appendix). In order to address these changes in measurement, Specific Aims I and II were evaluated cross-sectionally in both Waves I and III. The longitudinal analysis for Specific Aim III was completed using Wave III and later waves.

Missing Data

There are some missing data in several important independent variables that were used. Multiple imputation techniques were employed by HRS researchers in order to provide values for missing responses for important variables such as age and education. In other cases where missing data were not imputed by the HRS researchers, respondents with missing values were compared to respondents with complete data to see if they differed on the main variables of interest. The outcomes of these sensitivity analyses are presented in the discussion section.

VARIABLES

A list of both independent and dependent variables used in the analyses can be seen in Table 4.2. In addition, the coding for each variable is summarized in the table.

Table 4.2. Variables used to evaluate the relationships between race/ethnicity, physical activity, and cognitive function in late middle age and older adults from the Health and Retirement Study (1992-2002).

Variable	Definition
Dependent variables:	
Total recall 1992 (Aim I-II)	Combination of immediate recall and delayed recall items coded 0-40 with 40 being the most number of items recalled; Factor score created: range (-2.53 - 5.33).
Total recall 1996-2002 (Aim III)	Combination of immediate recall and delayed recall items coded 0-20 with 20 being the most number of items recalled. Factor score created: range (-3.01 - 2.58).
Mental Status 1996-2002 (Aim I-III)	Constructed by combining respondents' answers to questions naming the current month, day, year, day of the week, vice president, president, scissors, cactus, and counting backwards from 20; coded 0-10 with 10 being the most number of items answered correctly
Explanatory variables:	
Age (1992, 1996)	Respondents' age 51+ at baseline continuous and recoded into quintiles
Gender (1992)	Coded 1 if respondent is a female, and 0 if male
Race/ethnicity (1992)	
Non-Hispanic White (ref)	Coded 1 if the respondent is NH White, 0 otherwise
Non-Hispanic Black	Coded 1 if the respondent is NH Black, 0 otherwise
Hispanic	Coded 1 if the respondent is Hispanic, 0 otherwise
Education (1992)	Number of years of education continuous and recoded into categories (≤7, 8-11, 12, ≥13)
Household Income (1992, 1996)	1992 Income Aims I-II, 1996 Income Aim I- III recoded into quartiles with high income as the reference
Work Status (1992, 1996)	Coded 1 if the respondent reports currently working for pay, 0 otherwise
Marital Status (1992)	
Married (ref)	Coded 1 if the respondent is married, 0 otherwise

Table 4.2. Continued.

Variable	Definition
Explanatory Variables Continued	
Self-rated health (1992, 1996)	Respondents' assessment of his or her own health; Scale of 15-95 (poor-excellent)
Chronic Illnesses (1992, 1996)	Composed of 7 illnesses: diabetes, arthritis, lung disease, heart disease, cancer, hypertension, stroke; coded 0-7
Body mass index (1992)	Calculated with respondents' self-reported height and weight in 1992
Underweight	Coded 1 if the respondents' BMI is below 18.5, 0 otherwise
Normal weight (ref)	Coded 1 if the respondents' BMI is in the range of 18.5-24.9, 0 otherwise
Overweight	Coded 1 if the respondents' BMI is in the range of 25-29.9, 0 otherwise
Obese	Coded 1 if the respondents' BMI is 30 or more, 0 otherwise
Depressive Symptoms (1992, 1996)	CES-D score 0-8
Church Attendance (1992) (Social Engagement)	Frequency of religious service attendance; Scale of 0-4 (never, 1 or more times per year, 2-3 times per month, once a week, more than once a week)
Physical Activity	
Light (1992)	Frequency of engaging in light physical activity from never - 3 times/week or more; coded 0-4
Vigorous (1992)	Frequency of engaging in vigorous physical activity from never - 3 times/week or more; coded 0-4
Housework (1992)	Frequency of engaging in heavy housework activity from never - 3 times/week or more; coded 0-4
Vigorous (1996-2002)	Coded 1 if frequency of engaging in vigorous physical activity was 3 times/week or more; 0, otherwise
Work (1992, 1996-2002)	Frequency of engaging in physical activity at work from never to all or almost all of the time; coded 0-3

Dependent Variables

Cognitive Function

For specific Aims I and II, cognitive function outcome variables included memory (1992) and mental status items (1996). For Specific Aim III, cognitive function outcome variables included memory (1996-2002) and mental status items (1996-2002).

As mentioned previously, measures of cognitive function in the HRS changed across waves. At baseline, there were fewer measures of cognitive function than in future waves. The main cognitive function outcome measures in the study assessed memory and mental status. At Wave I, immediate and delayed recall tests were used to assess memory. Respondents were read a list of 20 words and asked to recall as many as possible. Five minutes later, after going through several other survey questions, they were asked to recall words from the list. The responses led to a possible total memory score of 0-40. Principal components analysis (PCA) with no rotation was used to examine whether the immediate and delayed recall questions were independent measures of cognitive function. Using PCA, 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 0.86. Therefore, the immediate and delayed items were converted into a factor score and standardized for use in the analyses.

At Wave III, different measures of cognitive function were available. These included mental status questions and recall variables (See Appendix A for measurement details). The mental status questions in the HRS, and those used for the current project, were derived from the Telephone Interview of Cognitive Status (TICS) (Brandt, 1988) and were comprised of a backwards count of at least 10 numbers beginning at the number 20 (attention/calculation), the current day, month, year, and day of the week (orientation), naming of objects described (scissors and cactus) (language), and naming the current President and Vice President of the United States (orientation) (Ofstedal et al., 2005). HRS administrators created a mental status summary score ranging from 0-10 that included orientation to time and date, counting backwards, object naming, and president and vice president naming. Using PCA and testing for reliability showed that the items did not load on a single factor measuring "cognitive function." This result was not surprising given the variety of cognitive domains the items assess. In the current research, therefore, the mental status score should be interpreted as a knowledge test comprised of mental status measures of orientation, concentration, and naming, rather than a general "cognitive function test." In 1998 and later, most of the items in the mental status measure were asked only of respondents who were 65 years of age or older and/or were new to the sample. Therefore, in the cross-sectional analyses of mental status, the total sample was used, but in the longitudinal analyses a sub sample of people who were 63 years of age or older in 1996 was used.

Memory was again assessed in Waves III-VI except that the number of words was reduced from 20 to 10. Therefore the range of scores on the total immediate and delayed recall items was 0-20. Again, PCA was used to create a standardized memory score. The results showed that the two variables were loaded on one factor, and was reliable (Cronbach's alpha=0.84). Because the recall items were used with the total sample, the longitudinal analyses using the total memory score were performed on all respondents in 1996 who were 51-61 in 1992. More detail on all of the PCAs and reliability tests can be found in the results in Chapter 5.

Independent Variables

Race/Ethnicity

In order to determine respondents' self-identified racial/ethnic group, they were asked, "Do you consider yourself primarily White or Caucasian, Black or African American, American Indian, or Asian, or something else?" They were also asked if they considered themselves Hispanic or Latino. For these analyses, respondents who identified themselves as white, black, or Hispanic or Latino were evaluated.

Physical Activity

To assess the contribution of physical activity to cognitive function, four measures of physical activity were incorporated in the cross sectional data analyses: (1) light activity, (2) vigorous activity, (3) housework activity, and (4) work-related activity. In the analyses, the physical activity measure(s) that correspond with the year from which the outcome measure came were used. In the HRS at Wave I, respondents were asked about their frequency of light, vigorous, and heavy housework activity. They could respond that they engage 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 addition, respondents were asked about physical activity at work in the following manner: "My job requires lots of physical effort. (Is this true all or almost all of the time, most of the time, some of the time, or none or almost none of the time?)" (range 0-3). Separate analyses were conducted for participants who work so that work physical activity could be evaluated properly.

In Wave III and later, respondents were asked about physical activity in a yes/no format (range 0-1). Two types of physical activities were assessed: (1) vigorous activity and (2) work-related activity. Respondents were asked, "On average over the last 12 months have you participated in vigorous physical activity or exercise three times a week or more? By vigorous physical activity, we mean things like sports, heavy housework, or a job that involves physical labor." This question replaced the three questions about leisure and housework activity frequency in Wave I. In addition, physical activity at work was assessed by the question, "My job requires lots of physical effort. Is this true almost all of the time, most of the time, some of the time, or none or almost none of the time?" (range 0-3). In the longitudinal portion of the analyses (Wave III and beyond), physical activity was a time-varying covariate.

Education

The educational level of respondents in the Health and Retirement Survey was assessed by asking respondents the highest grade of school they completed (range 1-17). Education was also recoded to reflect thresholds at which differences in cognitive test performance may be expected occur: less than or equal to 7 years, 8-11 years, 12 years, and 13 or more years of education.

Other Covariates

It was also important to include established correlates and predictors of physical activity and/or cognitive function in multivariable models in order to estimate the most complete models. There are additional variables included in the HRS data that are primary predictors or strong correlates of either cognitive change or physical activity. These included age, marital status, church attendance, chronic illnesses, depression, gender, self-rated health, household income, and body mass index (Albert et al., 1995; Nguyen et al., 2002; Eyler, 2003; Van Ness & Kasl, 2003). Increases in age are associated with decreases in levels of physical activity and increases in cognitive impairment (Albert et al., 1995; Brownson et al., 2000). These associations are partially due to bodily changes that occur with the aging process that prohibit activity, as well as the development of health conditions that affect cognitive function. Participants' ages ranged from 51-61 in Wave I of the study. In addition, age was explored as a categorical measure using quintiles: 51-52, 53-54, 55-56, 57-58, and 59-61.

At present, research is unclear regarding whether marital status is related to cognitive function or physical activity. However, research suggests that social support can contribute to better cognitive function and more physical activity (Marquez & McAuley, 1999; Eyler, 2003; Yeh & Liu, 2003; Zunzunegui et al., 2003; Barnes et al., 2004). On the other hand, research has suggested that marriage is associated with decreased vigorous physical activity in women (Sternfeld et al., 1999). In the current study, a measure of married versus not married was used in the analyses.

In addition to marital status, religious service attendance was included as a measure of social engagement. Church attendance has been associated with better scores on tests of cognitive function in white, black, and Mexican American adults (Van Ness & Kasl, 2003; Hill et al., 2006). The theory is that attending religious services is a form of social engagement, and subsequently cognitive engagement, which helps to preserve cognitive function (Bassuk et al., 1999; Van Ness & Kasl, 2003). HRS respondents were asked about religious service attendance and could report that they attended 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).

Other predictors of cognitive change are certain comorbid conditions such as vision impairment, stroke, and diabetes (Albert et al., 1995; Nguyen et al., 2002). Respondents were given one point if they reported having ever been diagnosed with hypertension, fracture, diabetes, cancer, stroke, lung disease, heart disease, and arthritis (range 0-8). This was done using the same techniques that researchers at the RAND Center for the Study on Aging used when they pooled the HRS and AHEAD data for use in longitudinal research (St. Clair et al., 2006). The only difference is that RAND researchers used a count of 0-9, where the ninth item indicated a history of diagnosed psychiatric or nervous problems. In this study, psychiatric problems were treated as a separate variable, and depressive symptoms were assessed.

Depressive symptoms, measured by questions from the Center for Epidemiologic Studies Depression scale (Radloff, 1977), were included in analyses. The flat affect that can accompany depression can be mistaken for cognitive impairment; therefore, it is important to account for depressive symptoms in studies of cognitive function (Satariano, 2005). In addition, depression has been linked to "motivation disturbances," comprised of difficulties concentrating, psychomotor problems, and energy loss, that can affect scores on tests of cognitive function (Forsell et al., 1994). In 1992, the HRS included traditionally scored (0-3 per item) items of the CES-D. Participants were asked if they felt depressed, felt like everything they did took a lot of effort, had restless sleep, were happy, were lonely, thought that people were unfriendly, enjoyed life, were sad, felt disliked, had trouble getting going, had a poor appetite, felt tired, and felt rested. They could respond that they felt this way none of the time, some of the time, most of the time, or all of the time. Scores ranged from 0-42. The measure, however, was inconsistent with future waves of the HRS. From 1994 and beyond, when questioned about depressive symptoms, respondents were asked similar, but fewer questions and could only respond that they either felt that way much of the time or not. This yielded scores of 0-1 per item with a total scale range from 0-8. To ensure comparability of the results of each Aim analysis, the 1992 CESD scores were recoded based on the way RAND researchers suggested when they pooled the HRS and AHEAD data for longitudinal analyses (St. Clair et al., 2006). In essence, the RAND researchers determined that 1992 CESD responses could be recoded into 0-1 variables by giving a score of one to those who responded most or all of the time and a score of zero to those who responded that they felt a certain way some or none of the time (St. Clair et al., 2006).

The remaining variables that were incorporated in the analyses are correlates of physical activity. These variables included sex, self-rated health, household income, and Body Mass Index (BMI). Sex is an important covariate because it has been shown that women have lower rates of physical activity than men (Eyler, 2003). Self-rated health (poor-excellent) is also important to include as a predictor of physical activity, because positive self-rated health enables people to adopt physically active lifestyles (Eyler, 2003). In this case, self-rated health was re-coded from 0-4 (poor-excellent) to 15-95 where 15=poor, 30=fair, 80=good, 90=very good, and 95=excellent. This technique was created by Diehr and colleagues who wanted a way to more adequately demonstrate the fact that self-rated health does not typically meet the proportional odds assumption (Diehr et al., 2001). Instead, the variable categories are spaced based on transformations performed by the researchers in order to show that if 0=dead and 100=perfect health, poor-excellent did not fall at even intervals (Diehr et al., 2001).

In addition, household income was accounted for because those in lower income brackets often have/perceive greater numbers of barriers to leisure time physical activity (Eyler, 2003). Household income was divided into four quartiles consistent with previous research using the HRS (Dunlop et al., 2003). Finally, BMI (mean=27.25 at Wave I) categories of underweight (<18.5), normal (18.5-24.9), overweight (25-29.9), or obese (30 or more) were accounted for since overweight individuals have been shown to engage in less physical activity (Trost et al., 1996).

ANALYSIS PLAN

In order to accomplish the aims of the study, multiple regression analyses, statistical tests of mediation, as well as mixed modeling for longitudinal data were conducted. Prior to addressing the specific aims, several analyses were used to demonstrate the similarity and reliability of the measures of cognitive function within and between each racial/ethnic group. In addition, to clarify some of the results, several sensitivity analyses were performed. All statistical analyses were performed using SAS version 9.1 (SAS Institute, 2004).

Measurement Consistency

In each racial/ethnic group, principal components analyses (PCA) and tests of reliability producing Cronbach's coefficient alphas were executed. The purpose of PCA is to determine if measures are independent or redundant (Jolliffe, 2002). In other words, PCA results can show if the measures of immediate recall and delayed recall are measuring separate concepts (independent) or are measuring the same concept (redundant). If the measures are redundant, they can be combined to create a more reliable scale (Jolliffe, 2002). In order to assess the internal consistency (reliability) of the scale, Cronbach's alphas were produced from the PROC CORR procedure in SAS (Cronbach, 1951; Carmines & Zeller, 1979). The results from each group were compared to each other and the total sample to demonstrate that both the factor loadings from the PCA and the reliability of each measure were consistent across racial/ethnic groups.

In addition to PCA and reliability analyses, multiple regression was also conducted within each group to ensure that each of the major correlates of cognitive function (age, education, depressive symptoms, chronic conditions, physical activity) were associated with cognitive function in the same direction. The results from these analyses were also compared to each other and the total sample.

Specific Aim I

Ordinary least squares regression (OLS) was utilized to investigate differences in cognitive function by race/ethnicity in the sample. This aim was examined using Wave I data (memory 0-40) and Wave III (mental status 0-10) separately due to the differences in measurement of cognitive function and physical activity. The following models were used to examine the relationship between race/ethnicity and cognitive function at baseline (separate analyses were conducted for each outcome and, in order to permit the utilization of the work physical activity measure, by work status):

Model 1: Yc= race/ethnicity

Model 2: Yc= race/ethnicity + sociodemographic measures + error

Model 3: Yc= Model 2 + health related and social measures + error

Model 4-6: Yc= Model 3 + physical activity (light, housework, vigorous) + error

Specific Aim II

To assess the cross sectional mediating effects of physical activity and education in the relationship between race/ethnicity and cognitive function, multiple regression and Sobel tests were conducted (Sobel, 1982). These were completed using data from Wave I (memory 0-40) and again using Wave III (mental status) for reasons stated above. In order to be considered a mediator, physical activity (or education) (Yp (or Ye)) must be associated with race/ethnicity, cognitive function (Yc) must be associated with race/ethnicity, and physical activity or education must be associated with cognitive function. The effect of race/ethnicity on cognitive function must be reduced when education and/or physical activity are entered into the models (Preacher & Hayes, 2004). Finally, a Sobel test was conducted to determine if the approximate indirect effect of race/ethnicity on cognition via physical activity or education is different from zero (Sobel, 1982; Baron & Kenny, 1986). This is consistent with similar research conducted by researchers using the Duke EPESE (Sachs-Ericsson & Blazer, 2005).

The following models were used to examine the cross-sectional mediating effects of education and physical activity in the relationship between race/ethnicity and cognitive function (Separate analyses were conducted for each outcome and, in order to permit the utilization of the work physical activity measure, by work status):

Model 1: Yc= race/ethnicity + error

Model 2: Yp= race/ethnicity + error

Model 3: Yc= physical activity or education + error

Model 4: Yc= race/ethnicity + physical activity or education + error

Analysis Plan: Specific Aim III

These exploratory analyses were conducted with longitudinal mixed models using repeated measures to test the effect of physical activity on cognitive decline in the context of race/ethnicity and to determine if there are disparities in rates of decline by race/ethnicity. The longitudinal analyses for the mental status variable were conducted only on those who were 63 years of age or older in 1996, but the analyses for memory used the total sample from 1996 and beyond. The models were performed using the PROC MIXED feature in SAS 9.1 (SAS Institute, 2004).

The purposes of using the MIXED procedure were two-fold. First, the MIXED procedure employs a maximum likelihood feature that accommodates the missing data due to attrition that occurs in longitudinal samples. Second, the MIXED procedure allows for time varying covariates to be included in the models. In this case, physical activity levels were entered as time-varying.

In addition, each model included the aforementioned dependent and independent variables as well as time interaction terms. The time interaction terms provided data points for mean cognitive function scores by race/ethnicity at each time in the presence of the model covariates. The data points were plotted to visually demonstrate cognitive function scores by race/ethnicity (while accounting for other variables). The mixed models were protected from inflation of Type I error due to repeated measures by using the Tukey posthoc test, and a p-value of 0.05 was used as the measure of statistical significance.

The following is an example of a model used to examine the longitudinal relationships between race/ethnicity, physical activity, and cognitive function (separate analyses were conducted for each outcome and, in order to permit the utilization of the work physical activity measure, by work status):

Yc= time + race/ethnicity + sociodemographic variables + health-related variables + physical activity + race/ethnicity*time + education*time + physical activity*time + error.

Chapter 5: Aim I Results

Chapters 5-7 summarize the results of the analyses used to address the specific aims. Results from the analyses are presented in several sections. In Chapter 5, results of principal components and reliability analyses of cognitive function measures, descriptive statistics of the sample and variables used, and cross-sectional results of the relationships between race/ethnicity and cognitive function in reference to Aim I are presented. In Chapter 6, the cross-sectional results regarding the mediating effects of physical activity on the relationships between race/ethnicity and cognitive function pertaining to Aim II are described. Finally, in Chapter 7, longitudinal results of the relationships between race/ethnicity and cognitive function related to Aim III are discussed.

DESCRIPTIVE STATISTICS

The sample used at Wave I of the HRS consisted of 9204 persons between the ages of 51-61 who were non-proxy and identified themselves as white, black, or Hispanic. The unweighted sample characteristics at baseline can be seen in Table 5.1.

Demographic Characteristics

The average age at baseline was approximately 56 years, and the study sample consisted of 55% women. White participants made up 73% of the sample with black and Hispanic participants making up 18% and 9%, respectively. In addition, the majority of the sample (75%) was married at baseline. The average years of education in the sample was 12, and over 30% of the sample completed 13 or more years of schooling. Furthermore, the average household income was approximately $47,000 per year. Lastly, over 65% of the sample reported at baseline that they currently worked for pay.

Table 5.1. Baseline descriptive statistics of a sample of late middle aged adults in the Health and Retirement Study (1992, 1996).

		HRS 92	HRS 96			HRS 92	HRS 96
Variable		(n=9204)	(n=7944)	**Variable**		(n=9204)	(n=7944)
Mental Status (0-10)		n/a	9.32 (1.06)	**M CESD**		1.75 (1.32)	1.29 (1.88)
Memory (0-40, 0-20)				**Church attendance**		79.83	80.51
(unstandardized)		12.81 (5.09)	11.07 (3.46)		Never	20.17	19.49
M (SD) Age		55.85 (3.13)	59.76 (3.14)		Once a year or more	23.31	23.35
% Female		55.33	56.43		2-3 times per month	16.3	16.32
Race/ethnicity					Once a week	24.4	24.76
	White	73.04	74.50		More than once a week	15.82	16.07
	Black	17.51	16.67	**Physical activity**			
	Hispanic	9.44	8.84		*Light Physical Activity*		
					3+/Week	52.66	n/a
M 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*		
M HH Income		$47,331 (56,969)	$53,321 (76,572)		3+/Week	12.87	50.56
	Quartile 1	25.46	25.02		1-2/Week	9.96	n/a
	Quartile 2	24.55	25.00		1-3/month	8.64	n/a
	Quartile 3	25.03	25.02		< 1/month	20.08	n/a
	Quartile 4	24.96	24.97		Never	48.44	n/a
% Working for pay		65.18	53.28		*Heavy House Work*		
% Married		75.74	76.54		3+/Week	8.44	n/a
Self rated health					1-2/Week	21.05	n/a
	Excellent	21.93	17.65		1-3/month	21.19	n/a
	Very Good	27.87	31.06		< 1/month	24.99	n/a
	Good	27.85	28.37		Never	24.34	n/a
	Fair	14.32	15.80		*Work Physical Activity (only those working)*		
	Poor	8.04	7.11		All/Almost All	21.39	19.58
M Chronic illnesses (0-7)		1.19 (1.13)	1.44 (1.21)		Most	18.83	17.44
BMI					Some	28.70	29.17
	Underweight	1.28	1.18		None/Does not work	31.08	33.82
	Normal Weight	33.26	33.33				
	Overweight	40.96	40.95				
	Obese	24.50	24.53				

NOTES: Refer to Table 4.1 for description of how coding of variables may have changed across time.

Health-Related and Social Characteristics

The participants' health was measured through assessments of self-rated health, depressive symptoms, body mass index, and number of chronic illnesses. Roughly 50% of the sample considered themselves to be in very good or excellent health, and the mean number of chronic illnesses per person was just over one. Over 65% of the sample had a BMI in the overweight or obese category, and the mean CES-D score at baseline was 1.75 (range 0-8). In addition, almost 80% of the sample reported attending church or religious services in the past month.

Cognitive Function

In 1992, the mean score on the memory test was 13 (range 0-40). In 1996, the average score was 11 (range 0-20). In addition, the average score on the mental status variable in 1996 was 9.32 (range 0-10), and for those over 63, who were evaluated in longitudinal analyses, the average score was 9.28. Reliability analyses were used to assess measurement consistency across racial/ethnic groups and the feasibility of using single factor scores for the outcome variables

Measurement Consistency

Reliability on scored data responses and principal components analyses (PCA) without rotation for memory and mental status were completed in each racial/ethnic group and compared to demonstrate that in each group, the cognitive measures had similar reliability and factor loadings. Similar analyses were performed by Ofstedal and colleagues on a larger set of HRS/AHEAD participants (2005). The results show that, with few exceptions, the ethnic groups do not differ with regard to their overall scores on either the mental status or memory tests. However, a lack of measurement bias was not confirmed

Memory

Each analysis showed a single factor solution indicating that the two measures could be combined to create a single, more reliable scale. In addition, the factor loadings were not different across ethnic groups. Furthermore, results of the Cronbach's measure of internal consistency showed that reliability was high and similar across groups. Table 5.2 shows the results of PCAs of the memory score components (immediate recall and delayed recall) for the total sample in 1992 (n=9204) as well as stratified by racial/ethnic group. The standardized range for the memory factor score was (-2.53-5.33).

Table 5.2. Principal components analyses factor loadings with eigenvalues and cronbach's alphas for memory items stratified by race/ethnicity in a sample of late middle aged adults (n=9204) from the Health and Retirement Study (1992).

	All (n=9204)	White (n=6723)	Black (n=1612)	Hispanic (n=869)
Immediate Recall	0.93	0.93	0.93	0.94
Delayed Recall	0.93	0.93	0.93	0.94
Eigenvalue (variance)	1.75 (87%)	1.73 (86%)	1.72 (86%)	1.76 (88%)
Cronbach's alpha	0.85	0.84	0.84	0.86

Mental Status

Somewhat different results were found with analyses of the mental status items. As mentioned previously, the items did not have high reliability. The summary score was interpreted as a count of items correct on a test of cognitive function. The score ranged from 0-10 with a mean (SD) of 9.3 (1.06). Reliability was adequate (for nine items) across all subjects (0.51).

Table 5.3 shows the results of PCAs of the mental status items day, date, month, year, president, vice president, scissors, cactus, and counting backwards from 20 for the sample in 1996 (n=7944). In the total sample, two factors were retained, but when stratified by race, three factors were retained in each racial/ethnic group. In most cases, the factor loadings were similar across groups. The factor loadings that varied were those for the "scissors" item. There was little consistency with this item due to low variance in responses (a very high rate of correct responses). Specific aim analyses without the "scissors" item were conducted and the results are presented in the sensitivity analysis section of the discussion chapter.

Results of reliability analysis of the mental status items by racial/ethnic group are also in Table 5.3. Though the grouping of the items results in low reliability, the alpha coefficients in each group are not different from each other or the total sample with the exception of white participants, where reliability is lower than that of the total sample or the other groups. This may lead to an underestimation in mental status score differences by race/ethnicity. Because the analysis did not yield a single factor solution, the mental status items were not combined in a standardized scale. Therefore, the original HRS-created count of 0-10 points was used as the outcome measure.

Table 5.3. Principal components analyses factor loadings, eigenvalues, and Cronbach's alphas for mental status items stratified by race/ethnicity in a sample of late middle aged adults (n=7944) from the Health and Retirement Study (1996).

	All (n=7944)		**White (n=5918)**			**Black (n=1324)**			**Hispanic (n=702)**		
	Factor 1	Factor 2	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3	Factor 1	Factor 2	Factor 3
Weekday	0.44	-0.44	0.45	-0.28	0.39	0.48	-0.44	0.01	0.61	-0.38	0.19
Date	0.40	-0.17	0.45	-0.22	-0.07	0.38	0.03	0.35	0.45	0.23	0.41
Month	0.49	-0.44	0.53	-0.36	-0.17	0.47	-0.44	0.003	0.64	-0.33	0.09
Year	0.58	-0.46	0.62	-0.32	0.05	0.56	-0.55	-0.11	0.70	-0.3	-0.08
President	0.52	0.36	0.45	0.58	0.06	0.58	0.28	-0.34	0.43	0.19	-0.63
Vice President	0.52	0.52	0.39	0.64	-0.09	0.53	0.51	-0.14	0.38	0.52	-0.46
Scissors	0.11	0.08	0.01	0.11	0.67	0.08	0.1	0.8	0.29	0.17	0.07
Cactus	0.46	0.44	0.27	0.31	0.16	0.52	0.4	-0.06	0.2	0.69	0.21
Backwards Count	0.34	0.20	0.22	0.09	-0.57	0.44	0.12	0.36	0.19	0.43	0.43
Eigenvalue (Variance)	1.8 (20%)	1.26 (14%)	1.54 (17%)	1.22 (14%)	1.03 (11%)	2.01 (22%)	1.21 (13%)	1.04 (12%)	1.97 (22%)	1.39 (15%)	1.07 (12%)
	All			**White**			**Black**			**Hispanic**	
Cronbach's alpha	0.51			0.36			0.57			0.57	

Correlates of Cognitive Measures by Race/Ethnicity

To address the similarity of cognitive measures for each racial/ethnic group, multiple regression analyses were performed to examine the direction of the relationship between cognitive function and each major correlate of cognitive function. In this case, a major correlate of cognitive function is one that is included in the study and consistently found to be an important predictor of cognition in the literature. Major correlates were age, education, self-rated health, depressive symptoms, chronic conditions, and physical activity.

Memory

Table 5.4 presents the results of the regression analyses (using standardized beta estimates) of correlates of cognitive function with memory, stratified by racial/ethnic group. In every case, the association between the independent variable and memory is of similar magnitude and significance. Age, chronic illnesses, and depressive symptoms were all negatively associated with memory score at baseline in the total sample and in each racial/ethnic group. Conversely, education, self-rated health, and vigorous physical activity were all positively associated with memory score at baseline in the total sample and in each racial/ethnic group. The results of these analyses showed that correlates of cognitive function did not associate differentially with memory score by racial/ethnic group.

Mental Status

Table 5.5 presents the results of the regression analyses (using standardized beta estimates) of correlates of cognitive function with mental status, stratified by racial/ethnic group. The results were somewhat different from memory in that age and vigorous physical activity associated differentially with mental status score by racial/ethnic group. Years of schooling, self-rated health, vigorous physical activity were each positively associated with mental status score at baseline in each racial/ethnic group. However there was no significant relationship ($p>0.05$) between vigorous physical activity and mental status score in white and Hispanic participants. Age, chronic illnesses, and CESD score were all negatively associated with mental status score. However, age was not significantly ($p>0.05$) related to mental status among white or Hispanic participants.

Overall, the reliability and factor loadings for the different cognitive function items were similar across racial/ethnic groups. In addition, the correlates of cognitive function were associated in the same direction with memory and mental status score by racial/ethnic group. 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 racial/ethnic group. Therefore, the analyses were completed using the single factor score for memory and the HRS-created summary score for mental status. Future research should employ techniques to confirm measurement invariance across groups.

Physical Activity

As previously discussed (see Table 4.2), physical activity variables had different coding in Wave I versus Wave III and beyond. Specifically, in Wave I, respondents were asked about light, housework, vigorous, and work-related physical activity, whereas in Waves III and beyond they were only asked about their vigorous activity and work-related physical activity. At baseline, over 50% of the sample reported engaging in light physical activity three or more times per week. In addition, approximately 13% and 8% of the sample reported that they engaged in vigorous or heavy housework activity three or more times per week, respectively. Also at baseline, among those who worked for pay, over 20% reported engaging in physical activity all or almost all of the time during work.

In Wave III (1996), the number of participants who reported engaging in vigorous activity three or more times per week was approximately 51%. The difference in Wave I and Wave III frequencies in this variable may be due to the elimination of other options from which to choose when answering the question. This study limitation was addressed further in the discussion section. In addition, for those who worked in 1996, almost 20% reported engaging in physical activity all or almost all of the time during work.

SPECIFIC AIM I RESULTS

The goal of Specific Aim I was to determine if there were differences in cognitive function by race/ethnicity in a representative sample of late middle age white, black, and Hispanic adults. The hypothesis for this aim was that black and Hispanic adults would have significantly lower scores on cognitive function tests than white adults. Bivariable and weighted multivariable regression analyses were used to test the hypothesis. Separate analyses were conducted for the total sample and for those who reported working for pay so that work physical activity could be included in multivariable models.

Bivariable Associations

The data were plotted to show the initial relationships between race/ethnicity and cognitive function prior to accounting for other variables. Figures 5.1 and 5.2 show that at baseline, black and Hispanic respondents had lower average scores on both memory and mental status tests than their white counterparts. For additional detail on these relationships, correlations between cognitive function and race/ethnicity can be seen in Tables 5.6 and 5.7. Being white was positively correlated and being black or Hispanic was negatively correlated with both memory and mental status. To assess if these differences could be explained by demographic, social, and health-related variables, multiple regression analyses were performed.

Table 5.4. Bivariable relationships between correlates of cognitive function and memory score by race/ethnicity in a sample (n=9204) of late middle aged adults from the Health and Retirement Study (1992). Presenting standardized beta estimates.

	All (n=9204)			White (n=6723)			Black (n=1612)			Hispanic (n=869)		
	β	p-value	r^2	β	p-value	r^2	β	p-value	r^2	β	p-value	r^2
Age	-0.11	<.0001	0.01	-0.11	<.0001	0.01	-0.12	<.0001	0.02	-0.13	0.0002	0.02
Years of School	0.34	<.0001	0.12	0.27	<.0001	0.07	0.35	<.0001	0.12	0.36	<.0001	0.13
Self-rated health	0.22	<.0001	0.05	0.16	<.0001	0.02	0.20	<.0001	0.04	0.20	<.0001	0.04
Chronic illnesses	-0.11	<.0001	0.01	-0.08	<.0001	0.01	-0.11	<.0001	0.01	-0.10	0.003	0.01
CESD	-0.16	<.0001	0.03	-0.11	<.0001	0.01	-0.19	<.0001	0.03	-0.12	0.0003	0.02
Vigorous activity	0.14	<.0001	0.02	0.10	<.0001	0.01	0.12	<.0001	0.01	0.13	0.0002	0.02

Table 5.5. Bivariable relationships between correlates of cognitive function and mental status score by race/ethnicity in a sample (n=7944) of late middle aged adults from the Health and Retirement Study (1996). Presenting standardized beta estimates.

	All (n=7944)			White (n=5918)			Black (n=1324)			Hispanic (n=702)		
	β	p-value	r^2	β	p-value	r^2	β	p-value	r^2	β	p-value	r^2
Age	-0.02	0.04	0.0005	-0.010	0.35	0.0002	-0.07	0.01	0.005	-0.06	0.15	0.003
Years of School	0.39	<.0001	0.15	0.24	<.0001	0.06	0.48	<.0001	0.23	0.38	<.0001	0.15
Self-rated health	0.27	<.0001	0.07	0.16	<.0001	0.03	0.27	<.0001	0.07	0.32	<.0001	0.11
Chronic illnesses	-0.13	<.0001	0.02	-0.10	<.0001	0.01	-0.11	<.0001	0.01	-0.16	0.003	0.02
CESD	-0.20	<.0001	0.04	-0.13	<.0001	0.02	-0.17	<.0001	0.03	-0.25	<.0001	0.06
Vigorous activity	0.06	<.0001	0.04	0.02	0.1376	0.0004	0.06	0.04	0.003	0.06	0.13	0.004

Multivariable Modeling Results

Memory Score

Table 5.8 displays the results of weighted multiple regression analyses investigating the relationships between race/ethnicity and total memory score. Model 1 shows the relationship between race/ethnicity and cognitive function, and indicates that those who were black or Hispanic had lower memory scores ($p<0.0001$). After sociodemographic variables such as age, gender, education, household income, working status, and marital status were entered into the model (Model 2), the significant relationships remained; however, the magnitude of the beta coefficients decreased by over 50% and 25% for Hispanics and blacks, respectively. In this model, females, married persons, and those who were working for pay had higher memory scores ($p<0.01$). In addition, participants who had less education had lower memory scores than those with 13 or more years ($p<0.0001$). In Model 3, with health-related variables, the significant relationships from Models 1 and 2 remained; however the coefficients corresponding to black and Hispanic persons decreased. Higher self-rated health was associated with a better memory score ($p<0.05$), and a greater number of depressive symptoms (CES-D score) was associated with a poorer memory score ($p<0.0001$).

In Models 4-6, different types of physical activity were added to the equations. The significant relationships from the previous models remained and, in addition, those who had higher levels of light physical activity and/or higher levels of vigorous physical activity had significantly higher scores on the memory test ($p<0.01$). Heavy housework was not associated with improved memory in the presence of other variables.

Figure 5.1. Mean (unstandardized) memory scores by race/ethnicity in a sample (n=9204) of late middle aged adults in the Health and Retirement Study (1992).

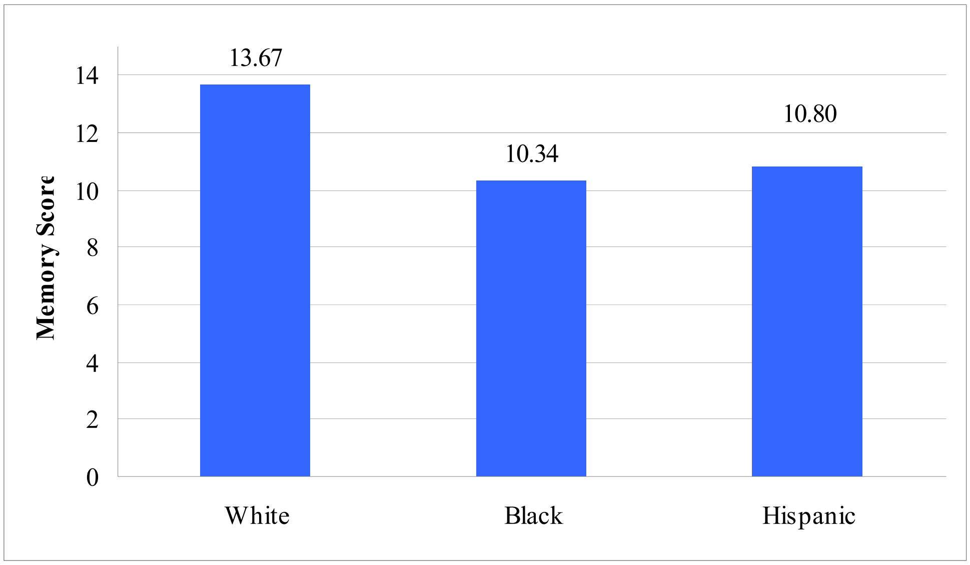


Figure 5.2. Mean mental status scores by race/ethnicity in a sample (n=7944) of late middle aged and older adults in the Health and Retirement Study (1996).

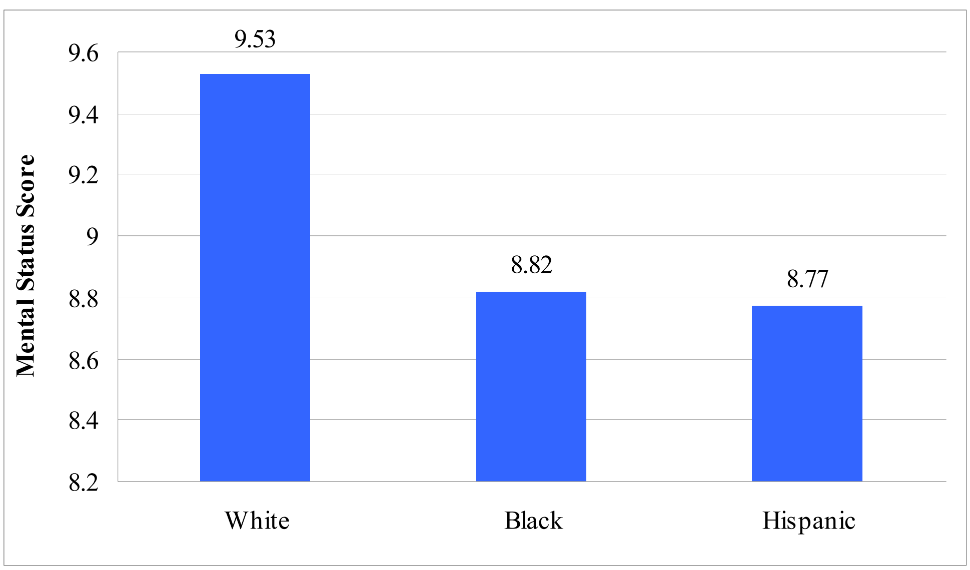


Table 5.6. Correlations at baseline among race/ethnicity, physical activity, education and memory score, in a sample (n=9204) of late middle age adults from the Health and Retirement Study (1992).

	Total Recall	White	Black	Hispanic	Light Activity	Vig Activity	House Activity	Work Activity*	Education
Total Recall	-								
White	0.28	-							
Black	-0.22		-						
Hispanic	-0.12			-					
Light Activity	0.11	0.11	-0.08	-0.06	-				
Vig Activity	0.14	0.14	-0.11	-0.07	0.32	-			
House Activity	0.03	-0.06	0.04	0.05	0.15	0.07	-		
Work Activity	-0.17	-0.16	0.12	0.09	-0.01 (ns)	-0.06	0.09	-	
Education	0.34	0.33	-0.11	-0.36	0.17	0.25	-0.05	-0.34	-

For all correlations, p<0.0001 (except between work activity and light activity)
* Correlation performed on only those who worked for pay in 1992

Table 5.7. Correlations at baseline among race/ethnicity, physical activity, education, and mental status score, in a sample (n=7944) of late middle age adults from the Health and Retirement Study (1996)

	Mental Status	White	Black	Hispanic	Vig Activity	Work Activity*	Education
Mental Status	-						
White	0.32	-					
Black	-0.18		-				
Hispanic	-0.24			-			
Vig Activity	0.07	0.09	-0.07	-0.06	-		
Work Activity	-0.21	-0.12	0.12	0.11	0.21	-	
Education	0.39	0.33	-0.12	-0.35	0.07	-0.33	-

For all correlations, p<0.0001
* Correlation performed on only those who worked for pay in 1996

Table 5.8. Results of multivariable regression analyses of the relationships between race/ethnicity and memory score in a sample (n=9204) of late middle age adults in the Health and Retirement Study (1992).

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)
Hispanic	-0.55	0.04 ***	-0.20	0.04 ***	-0.19	0.04 ***	-0.19	0.04 ***	-0.18	0.04 ***	-0.19	0.04 ***
Black	-0.65	0.03 ***	-0.47	0.03 ***	-0.45	0.03 ***	-0.45	0.03 ***	-0.45	0.03 ***	-0.45	0.03 ***
Age Q2			-0.07	0.04	-0.07	0.04	-0.07	0.04	-0.07	0.04	-0.07	0.04
Age Q3			-0.12	0.04 **	-0.13	0.04 **	-0.13	0.04 **	-0.13	0.04 **	-0.13	0.04 **
Age Q4			-0.15	0.04 ***	-0.16	0.04 ***	-0.16	0.04 ***	-0.16	0.04 ***	-0.16	0.04 ***
Age Q5			-0.23	0.03 ***	-0.24	0.03 ***	-0.24	0.03 ***	-0.23	0.03 ***	-0.24	0.03 ***
Female			0.39	0.02 ***	0.39	0.02 ***	0.39	0.02 ***	0.39	0.02 ***	0.39	0.02 ***
Education												
Less than 8 years			-0.83	0.05 ***	-0.78	0.05 ***	-0.77	0.05 ***	-0.76	0.05 ***	-0.78	0.05 ***
8-11 years			-0.53	0.03 ***	-0.50	0.03 ***	-0.49	0.03 ***	-0.48	0.03 ***	-0.50	0.03 ***
12 years			-0.27	0.03 ***	-0.25	0.03 ***	-0.25	0.03 ***	-0.25	0.03 ***	-0.25	0.03 ***
HH Income Q1			-0.18	0.04 ***	-0.14	0.04 **	-0.14	0.04 **	-0.13	0.04 **	-0.14	0.04 **
HH Income Q2			-0.12	0.03 **	-0.11	0.03 **	-0.11	0.03 **	-0.10	0.03 **	-0.11	0.03 **
HH Income Q3			-0.02	0.03	-0.02	0.03	-0.01	0.03	-0.01	0.03	-0.02	0.03
Working			0.07	0.02 **	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.03
Married			0.11	0.03 **	0.09	0.03 *	0.09	0.03 *	0.09	0.03 *	0.09	0.03 **
Self rated health					0.001	0.001 *	0.001	0.001 *	0.001	0.001 *	0.001	0.001 *
Chronic illnesses (0-7)					0.000	0.01	0.000	0.01	0.001	0.01	0.0001	0.01
Underweight					0.05	0.10	0.05	0.09	0.05	0.09	0.05	0.10
Overweight					-0.01	0.03	-0.01	0.03	-0.01	0.03	-0.01	0.03
Obese					-0.04	0.03	-0.03	0.03	-0.03	0.03	-0.04	0.03
CESD (0-8)					-0.05	0.01 ***	-0.05	0.01 ***	-0.05	0.01 ***	-0.05	0.01 ***
Goes to Church					-0.001	0.01	-0.002	0.01	-0.002	0.01	-0.001	0.01
Light Physical Activity							0.03	0.01 **				
Vigorous Physical Activity									0.03	0.01 **		
Heavy House Work											-0.003	0.01

Notes:
* p≤0.05
** p≤0.01
*** p≤0.001

Memory Score - Working Subsample

Table 5.9 shows the results of OLS regression models that test the cross-sectional relationship between race/ethnicity and cognitive function in those who were working for pay in 1996 (n=5987). In general, similar results to the whole sample were found.

In Model 1, race/ethnicity was strongly negatively associated with cognitive function indicating that being black or Hispanic was associated with lower scores on the memory test than being white. However, in Model 2, when demographic variables were entered, the magnitude of the beta coefficient for Hispanic ethnicity dropped by over 50%. The relationship between being black and memory score also dropped. In addition, lower levels of education were associated with lower scores on the memory test as were the two lowest levels of household income ($p<0.0001$).

In Model 3, when health-related and social variables were entered into the model, self-rated health was not significantly related to memory as it was in the total sample. However, a greater number of depressive symptoms (CESD) was still significantly related to poorer memory scores similar to results found in the whole sample ($p<0.0001$). Race/ethnicity continued to be associated with memory score.

In Models 4-6, different types of physical activities were examined as model covariates. First, unlike other types of physical activity in the models for the total sample, greater physical activity at work was associated with poorer memory scores ($p<0.05$). Furthermore, this negative association remained significant even when other types of activity were accounted for in the remaining models. As in the total sample, both light and vigorous physical activity were positively associated with higher memory scores ($p<0.05$). There were no notable differences in the demographic, health, and social variables from Model 3 after physical activities were added. Still, in the final models, race/ethnicity remained associated with lower memory scores.

Mental Status Score

Table 5.10 shows the relationship between race/ethnicity and mental status score when accounting for covariates. Similarly to memory, in Model 1, black and Hispanic adults had lower mental status scores than white adults ($p<0.0001$). As with memory, the association of ethnicity and mental status was reduced after accounting for SES variables. In Model 2, less education and lower income were significantly associated with lower mental status scores ($p<0.05$). In addition, working was associated with higher scores.

In Model 3, when health-related and social variables were entered, the relationship between race/ethnicity and mental status was not further reduced. Education and income levels continued to be associated with the mental status score ($p<0.05$), but working was no longer statistically related. Most health-related and social variables were not significantly associated with mental status in Model 3, with the exception of self-rated health and CES-D score. Positive self-rated health was related to higher mental status scores ($p<0.05$), and more depressive symptoms were associated with lower scores ($p<0.05$).

In the final model, the only measure of physical activity that was able to be included from the 1996 survey was whether or not the respondent said they engaged in vigorous physical activity three times per week or more. Despite evidence of a relationship seen in the bivariable correlation, vigorous activity was not significantly associated with mental status score once the other covariates were present in Model 4. The race/ethnicity effect remained constant across models 2-4.

Table 5.9. Results of multivariable regression analyses of the relationships between race/ethnicity and memory score in a sample (n=5987) of late middle age adults who worked for pay in the Health and Retirement Study (1992).

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)	Model 6	(SE)	Model 7	(SE)
Hispanic	-0.44	0.06 ***	-0.14	0.09 *	-0.13	0.06 *	-0.13	0.06 *	-0.13	0.06 *	-0.13	0.06 *	-0.13	0.06 *
Black	-0.58	0.04 ***	-0.45	0.04 ***	-0.44	0.04 ***	-0.43	0.04 ***	-0.43	0.04 ***	-0.43	0.04 ***	-0.43	0.04 ***
Age Q2			-0.10	0.04 *	-0.10	0.04 *	-0.10	0.04 *	-0.10	0.04 *	-0.10	0.04 *	-0.10	0.04 *
Age Q3			-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **	-0.16	0.04 **	-0.17	0.04 **
Age Q4			-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **	-0.17	0.04 **
Age Q5			-0.24	0.04 ***	-0.25	0.04 ***	-0.25	0.04 ***	-0.25	0.04 ***	-0.24	0.04 ***	-0.25	0.04 ***
Female			0.39	0.03 ***	0.39	0.03 ***	0.39	0.03 ***	0.39	0.03 ***	0.40	0.03 ***	0.39	0.03 ***
Education														
Less than 8 years			-0.79	0.07 ***	-0.75	0.07 ***	-0.72	0.07 ***	-0.70	0.07 ***	-0.70	0.07 ***	-0.72	0.07 ***
8-11 years			-0.54	0.04 ***	-0.52	0.04 ***	-0.49	0.04 ***	-0.49	0.04 ***	-0.48	0.04 ***	-0.49	0.04 ***
12 years			-0.29	0.03 ***	-0.28	0.03 ***	-0.26	0.03 ***	-0.26	0.03 ***	-0.26	0.03 ***	-0.26	0.03 ***
HH Income Q1			-0.19	0.05 **	-0.17	0.05 **	-0.16	0.05 **	-0.15	0.05 **	-0.14	0.05 **	-0.16	0.05 **
HH Income Q2			-0.19	0.04 ***	-0.18	0.04 ***	-0.16	0.04 ***	-0.16	0.04 **	-0.15	0.04 **	-0.16	0.04 ***
HH Income Q3			-0.05	0.04	-0.04	0.04	-0.03	0.04	-0.03	0.04	-0.03	0.04	-0.03	0.04
Married			0.06	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04	0.04	0.04
Self rated health					0.001	0.001	0.001	0.001	0.0005	0.001	0.0004	0.001	0.001	0.001
Chronic illnesses (0-7)					0.00	0.02	-0.001	0.02	-0.001	0.02	0.001	0.02	-0.001	0.02
Underweight					-0.03	0.15	-0.02	0.15	-0.03	0.14	-0.02	0.15	-0.02	0.15
Overweight					-0.03	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03	-0.02	0.03
Obese					-0.05	0.04	-0.05	0.04	-0.04	0.04	-0.04	0.04	-0.05	0.04
CESD (0-8)					-0.06	0.01 ***	-0.06	0.01 ***	-0.05	0.01 ***	-0.05	0.01 ***	-0.06	0.01 ***
Goes to Church					0.01	0.01	0.003	0.01	0.002	0.01	0.002	0.01	0.003	0.01
Work Physical Activity							-0.04	0.01 **	-0.04	0.01 **	-0.04	0.01 **	-0.04	0.01 **
Light Physical Activity									0.02	0.01 *				
Vigorous Physical Activity											0.03	0.01 **		
Heavy House Work													-0.001	0.01

Notes:
* p≤0.05
** p≤0.01
*** p≤0.001

Table 5.10. Results of multivariable regression analyses of the relationships between race/ethnicity and mental status score in a sample (n=7944) of late middle age adults in the Health and Retirement Study (1996).

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)
Hispanic	-0.75	0.06 ***	-0.25	0.05 ***	-0.24	0.06 ***	-0.24	0.06 ***
Black	-0.76	0.05 ***	-0.55	0.04 ***	-0.53	0.04 ***	-0.54	0.04 ***
Age Q2			0.03	0.03	0.03	0.03	0.03	0.03
Age Q3			0.03	0.04	0.03	0.04	0.03	0.04
Age Q4			0.06	0.03	0.05	0.03	0.05	0.03
Age Q5			0.06	0.03	0.05	0.03	0.05	0.03
Female			0.04	0.02	0.03	0.02	0.03	0.02
Education								
Less than 8 years			-1.07	0.08 ***	-1.00	0.08 ***	-1.00	0.08 ***
8-11 years			-0.46	0.04 ***	-0.42	0.04 ***	-0.42	0.04 ***
12 years			-0.16	0.02 ***	-0.14	0.02 ***	-0.14	0.02 ***
HH Income Q1			-0.27	0.04 ***	-0.20	0.04 ***	-0.20	0.04 ***
HH Income Q2			-0.10	0.03 **	-0.07	0.03 *	-0.07	0.03 *
HH Income Q3			-0.02	0.03	-0.01	0.03	-0.01	0.03
Working			0.08	0.02 **	0.04	0.02	0.04	0.02
Married			0.02	0.03	0.004	0.03	0.004	0.03
Self rated health					0.003	0.001 ***	0.003	0.001 ***
Chronic illnesses (0-7)					-0.003	0.01	-0.004	0.01
Underweight					-0.18	0.14	-0.19	0.14
Overweight					0.01	0.02	0.01	0.02
Obese					0.02	0.03	0.01	0.03
CESD (0-8)					-0.03	0.01 **	-0.03	0.01 **
Goes to Church					0.001	0.01	0.001	0.01
Vigorous Physical Activity							-0.04	0.02

Notes:
* $p \leq 0.05$
** $p \leq 0.01$
*** $p \leq 0.001$

Mental Status Score - Working Subsample

In the sample of those who reported working for pay in 1996 (n=4219), being black or Hispanic was associated with lower mental status scores than being white (p<0.0001) (Table 5.11). In Model 2, however, Hispanic ethnicity was no longer associated with mental status score, but being black was still significantly negatively associated (p<0.0001) with the score. In addition, as in the total sample, lower levels of income and less than 13 years of education were significantly associated with lower mental status scores.

Model 3 adjusted health-related and social variables in order to help explain the remaining relationship between race/ethnicity and mental status score. Being black was significantly associated with lower scores on the mental status test, and education and income remained associated. Like the total sample, respondents who worked for pay, had higher scores, as well as those who had more positive self-health ratings ($p<0.0001$). Conversely, CES-D was not significantly associated with mental status score in those who worked for pay. Lastly, underweight body mass index was associated with higher mental status scores ($p<0.0001$).

Physical activity measures were examined in Models 4 and 5. In Model 4, as was the case with memory, work physical activity was negatively associated with mental status ($p<0.0001$). Furthermore, similarly to the total sample, vigorous physical activity was not associated with mental status. Being black remained significantly negatively associated with mental status score in both models ($p<0.0001$), and Hispanic ethnicity remained unassociated.

SPECIFIC AIM I SUMMARY

The goal of Specific Aim I was to determine if race/ethnicity was associated with lower scores on tests of cognitive function in late middle aged adults in the Health and Retirement Study, after adjusting for demographic (especially socioeconomic status), health-related, and social variables. Results indicated that, in general, being black or Hispanic was negatively associated with scores on tests of memory and mental status, and being white was positively associated with the scores. Being black was significantly negatively associated with memory and mental status scores in the total sample and in the sample of those who worked. On the other hand, demographic variables (age, education, income, marital status, and work status) reduced the association that existed between

Hispanic ethnicity and mental status scores in the sample of those who worked for pay, so that it was no longer significant.

Table 5.11. Results of multivariable regression analyses of the relationships between race/ethnicity and mental status score in a sample (n=4219) of late middle age adults who worked for pay in the Health and Retirement Study (1996).

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)
Hispanic	-0.48	0.07 ***	-0.11	0.06	-0.09	0.06	-0.09	0.07	-0.09	0.07
Black	-0.53	0.05 ***	-0.38	0.05 ***	-0.38	0.05 ***	-0.37	0.05 ***	-0.37	0.05 ***
Age Q2			0.01	0.04	0.02	0.04	0.02	0.04	0.02	0.04
Age Q3			-0.01	0.04	0.00	0.04	0.01	0.04	0.01	0.04
Age Q4			0.05	0.04	0.05	0.04	0.05	0.04	0.05	0.04
Age Q5			0.02	0.04	0.03	0.04	0.05	0.05	0.05	0.05
Female			-0.01	0.03	-0.01	0.03	-0.03	0.03	-0.03	0.03
Education										
Less than 8 years			-1.03	0.11 ***	-1.00	0.10 ***	-1.00	0.12 ***	-1.00	0.12 ***
8-11 years			-0.43	0.05 ***	-0.41	0.05 ***	-0.39	0.06 ***	-0.39	0.06 ***
12 years			-0.12	0.03 ***	-0.11	0.03 ***	-0.07	0.03 *	-0.07	0.03 *
HH Income Q1			-0.31	0.07 ***	-0.26	0.06 ***	-0.18	0.06 **	-0.18	0.06 **
HH Income Q2			-0.18	0.04 ***	-0.17	0.04 ***	-0.11	0.04 *	-0.11	0.04 *
HH Income Q3			-0.06	0.03 *	-0.05	0.03	-0.01	0.03	-0.01	0.03
Married			-0.02	0.04	-0.02	0.04	-0.04	0.04	-0.03	0.04
Self rated health					0.003	0.001 **	0.003	0.001 **	0.003	0.001 **
Chronic illnesses (0-7)					0.01	0.01	0.02	0.01	0.02	0.01
Underweight					0.24	0.09 **	0.22	0.08 **	0.22	0.08 **
Overweight					0.05	0.03	0.04	0.03	0.04	0.03
Obese					0.04	0.04	0.02	0.04	0.01	0.04
CESD (0-8)					-0.02	0.01	-0.03	0.01	-0.03	0.01
Goes to Church					-0.001	0.01	-0.01	0.01	-0.01	0.01
Work Physical Activity							-0.08	0.01 ***	-0.07	0.01 ***
Vigorous Physical Activity									-0.02	0.03

Notes:
* p≤0.05
** p≤0.01
*** p≤0.001

Chapter 6: Aim II Results

The goal of Specific Aim II was to determine if mediating relationships existed among race/ethnicity, education and/or physical activity, and cognitive function. The hypothesis pertaining to Specific Aim II was that, in a sample of late middle aged adults, both education and physical activity would mediate the relationship between race/ethnicity and cognitive function. The expectation was that the magnitude of the relationships between race/ethnicity and cognition would decrease when adjusted for education or physical activity in multivariable modeling. In addition to multivariable modeling, Sobel tests, statistical tests of mediation, were conducted. Separate analyses were conducted for the total sample and for those who reported working for pay so that work physical activity could be included in multivariable models.

As stated previously, a set of variables must meet several requirements to have a mediating relationship. In this case, physical activity or education must be significantly associated with race/ethnicity, race/ethnicity must be significantly associated with cognitive function, and physical activity or education must be significantly associated with cognitive function. A visual description of these relationships can be found in Figure 1.1.

SPECIFIC AIM II RESULTS

Race/Ethnicity, Physical Activity, and Memory

Bivariable Relationships

The data were plotted to show the initial relationships between race/ethnicity, physical activity and memory prior to accounting for other variables. Figures 5.1 and 6.1-6.4 show that at baseline and before accounting for other demographic, social, and health factors, black and Hispanic respondents, as well as those who had lower levels of light, vigorous, and housework activity, or higher levels of work physical activity had lower average scores on the memory test. Tables 5.6 and 5.7 showed the results of correlations between race/ethnicity, physical activity, and cognitive function (memory and mental status). In Table 5.6, ethnicity was correlated with leisure-time physical activity such that being white was associated with increased activity ($p<0.0001$) and being black or Hispanic was related to decreased activity ($p<0.0001$). Conversely, being white was correlated with decreased housework and work-related activity ($p<0.0001$), whereas being black or Hispanic was related to increased house and work-related activity ($p<0.0001$). Furthermore, being white was correlated with higher memory scores, and being black or Hispanic was associated with lower memory scores ($p<0.0001$). Finally, light, vigorous, and heavy housework activity were all associated with higher memory scores, and work physical activity was associated with lower scores ($p<0.0001$). Similar results were found with mental status.

Figure 6.1 Mean (unstandardized) memory scores by light physical activity in a sample (n=9204) of late middle aged adults in the Health and Retirement Study (1992).

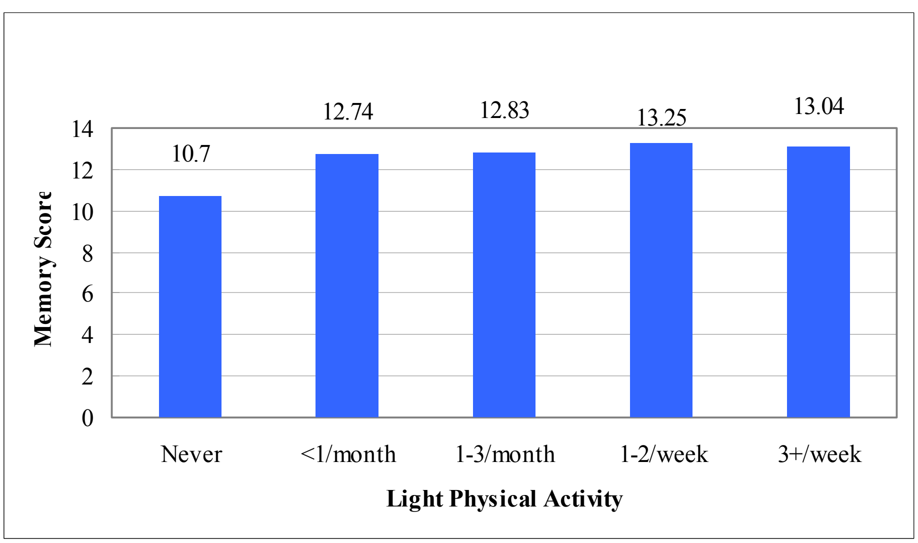


Figure 6.2 Mean (unstandardized) memory scores by vigorous physical activity in a sample (n=9204) of late middle aged adults in the Health and Retirement Study (1992).

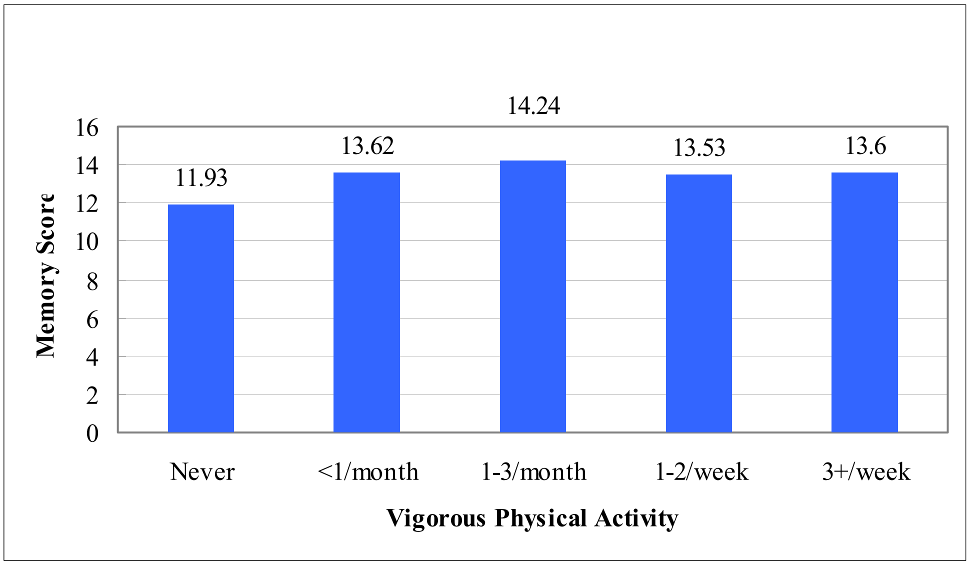


Figure 6.3 Mean (unstandardized) memory scores by housework physical activity in a sample (n=9204) of late middle aged adults in the Health and Retirement Study (1992).

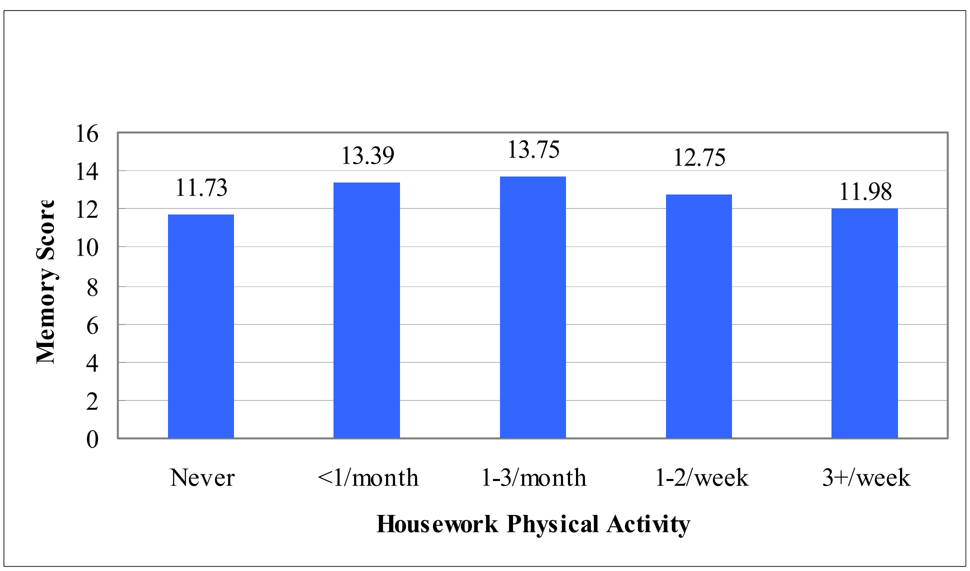
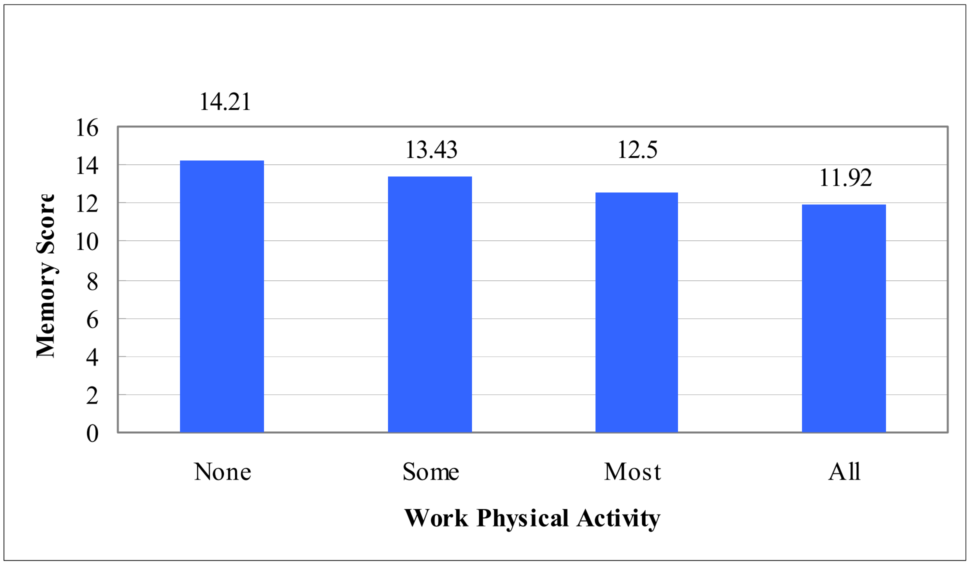


Figure 6.4 Mean (unstandardized) memory scores by work-related physical activity in a sample (n=5987) of late middle aged adults in the Health and Retirement Study (1992) who reported working for pay.



In the sample in 1996 (Table 5.7), Hispanic and black race/ethnicity was negatively associated with vigorous activity 3 times per week or more, and white race/ethnicity was positively associated with engaging in vigorous activity ($p<0.0001$). Similarly to memory score, race/ethnicity was significantly correlated with mental status in that those who were black or Hispanic had lower mental status scores, than white respondents ($p<0.0001$). Lastly, vigorous activity was positively correlated with the mental status scores, but work activity was negatively associated with scores ($p<0.0001$).

Regression Results

In order to be in a mediating relationship, race/ethnicity, physical activity, and cognitive function must first be significantly related in regression analyses. To demonstrate that the initial relationships existed, OLS regression results can be found in Tables 6.1-6.3. First, in Table 6.1A, race/ethnicity was significantly related to memory score in that black and Hispanic adults had lower memory scores than white adults (p<0.0001). These relationships also existed in the subsample of those who worked for pay (see Table 6.1B).

Table 6.1. Results of multivariable regression analyses of the relationship between race/ethnicity and memory score in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Hispanic	-0.549	0.04	***
Black	-0.649	0.03	***

B. Working Subsample (n=5987)

		(SE)	
Hispanic	-0.437	0.06	***
Black	-0.577	0.04	***

The next requirement for mediation is that physical activity is associated with race/ethnicity. Table 6.2 indicates that, in most cases race/ethnicity was associated with physical activity. Relationships that were exhibited in the correlations tended to exist in the regression results as well. Being black or Hispanic was negatively associated with engaging in vigorous or light physical activity (p<0.0001). Conversely, being black or Hispanic was positively associated with work-related activity (p<0.0001), and Hispanic ethnicity, but not being black, was positively associated with housework activity (p<0.0001).

The next requirement for mediation is that physical activity must be related to cognitive function. Increased vigorous, light, and housework activity were associated with higher memory scores (p<0.0001) (Table 6.3a-c). On the other hand, as shown in Table 6.3d, work-related physical activity was associated with lower scores on the memory test (p<0.0001).

Table 6.2. Results of multivariable regression analyses of the relationship between race/ethnicity and physical activity (vigorous (A), light (B), housework (C), and work-related (D)) in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Hispanic	-0.48	0.05	***
Black	-0.41	0.04	***

B. Total Sample (n=9204)

		(SE)	
Hispanic	-0.29	0.06	***
Black	-0.31	0.05	***

C. Total Sample (n=9204)

		(SE)	
Hispanic	0.23	0.06	***
Black	0.08	0.04	

D. Working Subsample (n=5987)

		(SE)	
Hispanic	0.42	0.06	***
Black	0.38	0.04	***

Table 6.3. Results of multivariable regression analyses of the relationship between physical activity (vigorous (a), light (b), housework (c), and work-related (d)) and memory score in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Vig Activity	0.09	0.01	***

B. Total Sample (n=9204)

		(SE)	
Light Activity	0.08	0.01	***

C. Total Sample (n=9204)

		(SE)	
House Activity	0.04	0.01	***

D. Working Subsample (n=5987)

		(SE)	
Work Activity	-0.14	0.01	***

Based on the results from the analyses, it was expected that physical activity may decrease the magnitude of the relationship between race/ethnicity and memory score, with the exception of work-physical activity and, in the case of black respondents, house physical activity. In order to test these ideas, Sobel tests were performed to determine if there was evidence of statistical mediation (Sobel, 1982).

Sobel Test Results

A Sobel test is a conservative statistical z-test that was used to test the hypothesis that the relationship between race/ethnicity and cognitive function was significantly reduced in the presence of the physical activity measure (Sobel, 1982; Preacher & Hayes, 2004). This method is consistent with other research in the field of cognitive function (Sachs-Ericsson & Blazer, 2005). Mediation has occurred when the result of the z-test falls outside the critical value of +/-1.96 (Sobel, 1982). Sobel test results for the mediation effects of different types of physical activities can be found in Table 6.4. The test results showed that statistical mediation occurred in each case with the exception of the relationship between being black, house-related physical activity, and memory. In addition, the positive z-value indicates that, when house activity is in a multivariable model with race/ethnicity, the negative relationship between race/ethnicity and physical activity may be stronger.

Table 6.4. Results of Sobel tests of the mediating effect of physical activity in the relationship between race/ethnicity and memory score in late middle aged adults from the Health and Retirement Study (1992).

	Vigorous Activity	Light Activity	House Activity
Hispanic	z=-6.23 (p<0.0001)	z=-5.03 (p<0.0001)	z=3.06 (p<0.01)
Black	z=-6.34 (p<0.0001)	z=-4.22 (p<0.0001)	z=1.80 (p=0.07)

Comparing Tables 6.1 and 6.5 facilitates the interpretation of the mediating relationship. Table 6.5 includes the results of multivariable regression analyses of race/ethnicity and different types of physical activity predicting memory score. When compared to results in Table 6.1, it is apparent that the magnitude of the relationship between race/ethnicity and cognitive function decreases when different forms of physical activity are included. These results suggest a partial mediation effect between race/ethnicity and memory and leisure time physical activity. However, as seen in 6.5C, housework activity, though positively associated with memory score, enhances the negative relationship between Hispanic ethnicity and cognitive function.

The coefficients used in the Sobel test were from simple mediation models. In other words, other covariates were not accounted for in the models. Currently, the use of Sobel tests has been approved and is recommended for simple tests of mediation (Baron & Kenny, 1986; Preacher & Hayes, 2004), however, some recent research on cognitive decline has conducted Sobel tests on coefficients that have been adjusted for other covariates (Sachs-Ericsson & Blazer, 2005). Because the positive associations found in current literature between education and leisure time activity, the Sobel tests were repeated while accounting for education. In the repeated analyses light and vigorous activity mediated the association between being black and memory score ($p<0.01$), but there was no evidence of statistical mediation between being Hispanic and memory score. Following the analyses of memory, mental status was examined.

Race/Ethnicity, Physical Activity, and Mental Status

Regression Analyses Results

The data were plotted to show the initial relationships between race/ethnicity, physical activity and memory prior to accounting for other variables. Figures 5.2 and 6.5-6.6 show that at baseline and before accounting for other demographic, social, and health factors, black and Hispanic respondents, as well as those who had lower levels of vigorous activity or higher levels of work physical activity had lower average scores on the memory test. Similar to previous analyses, the results of the tests of mediation among race/ethnicity, physical activity, and mental status can be found in Table 6.6-6.8. In these tables, race/ethnicity was significantly related to mental status score in the total sample and in the subsample of those who were working for pay in 1996 (Table 6.6). Black and Hispanic adults had lower mental status scores than white adults (p<0.0001).

Figure 6.5 Mean mental status scores by vigorous physical activity in a sample (n=7944) of late middle aged adults in the Health and Retirement Study (1996).

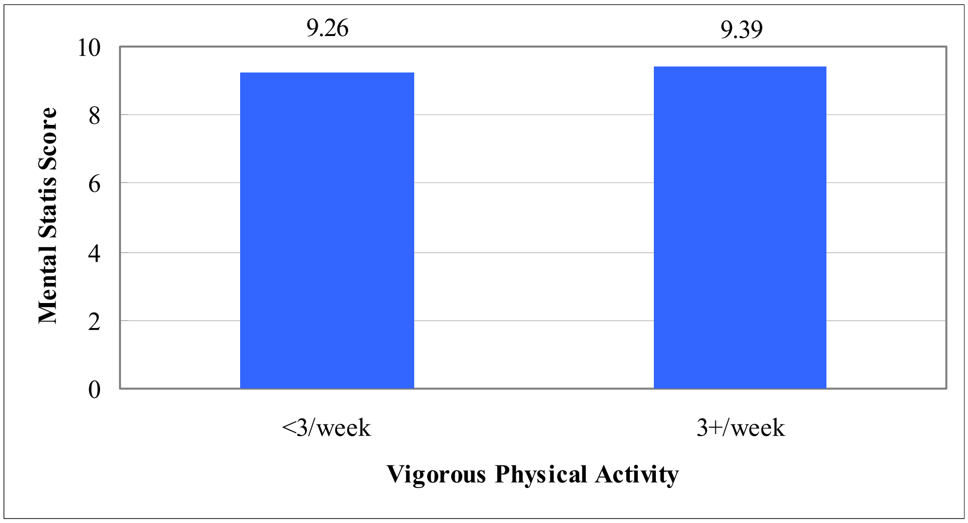


Figure 6.6 Mean mental status scores by work-related physical activity in a sample (n=4219) of late middle aged adults in the Health and Retirement Study (1996) who reported working for pay.

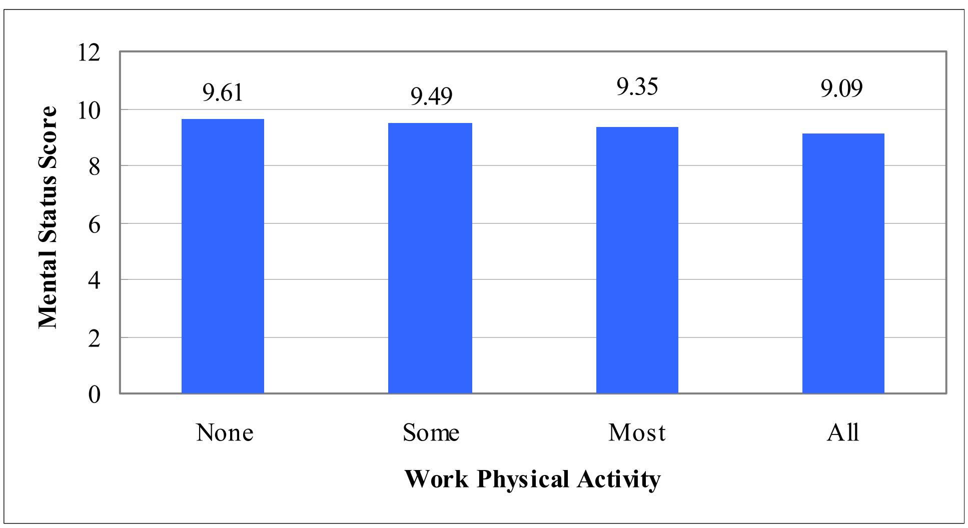


Table 6.5: Results of multivariable regression analyses of the relationships among race/ethnicity, physical activity (vigorous (a), light (b), and housework (c)) and memory score in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)
Hispanic	-0.515	0.04 ***
Black	-0.620	0.03 ***
Vigorous Activity	0.071	0.01 ***

B. Total Sample (n=9204)

		(SE)
Hispanic	-0.531	0.04 ***
Black	-0.630	0.03 ***
Light Activity	0.064	0.01 ***

C. Total Sample (n=9204)

		(SE)
Hispanic	-0.559	0.04 ***
Black	-0.654	0.03 ***
House Activity	0.047	0.01 ***

Similarly to memory, physical activity was associated with race/ethnicity in 1996. In Table 6.7, it is evident that being Hispanic or black was negatively associated with reporting engaging in vigorous physical activity 3 times per week or more ($p<0.0001$), and positively associated with reporting engaging in work-related physical activity ($p<0.0001$). The final requirement for mediation is that physical activity must be related to the mental status items score, and in both cases (vigorous and work-related), activity was significantly related ($p<0.0001$). However, vigorous activity was positively associated with mental status, while work activity was negatively related (See Table 6.8).

Table 6.6. Results of multivariable regression analyses of the relationship between race/ethnicity and mental status score (range 0-10) in late middle aged adults from the Health and Retirement Study (1996). Presenting unstandardized beta estimates.

A: Total Sample (n=7944)

		(SE)
Hispanic	-0.750	0.06 ***
Black	-0.763	0.05 ***

B: Working Subsample (n=4219)

		(SE)
Hispanic	-0.481	0.07 ***
Black	-0.532	0.05 ***

Table 6.7: Results of logistic and multivariable regression analyses of the relationship between race/ethnicity and physical activity (vigorous (a) and work-related (b)) in late middle aged adults from the Health and Retirement Study (1996). Presenting unstandardized beta estimates.

A. Total Sample (n=7944)

		(SE)
Hispanic	-0.44	0.09 ***
Black	-0.43	0.07 ***

B. Working Subsample (n=4219)

		(SE)
Hispanic	0.48	0.08 ***
Black	0.45	0.06 ***

Table 6.8: Results of multivariable regression analyses of the relationship between physical activity (vigorous (a) and work related (b)) and mental status in late middle aged adults from the Health and Retirement Study (1996). Presenting unstandardized beta estimates.

A: Total Sample (n=7944)

		(SE)
Vigorous Activity	0.11	0.02 ***

B: Working Subsample (n=4219)

		(SE)
Work Activity	-0.15	0.01 ***

The results of the analyses showed that vigorous activity met the requirements as a mediator between race/ethnicity and mental status and was expected to decrease the magnitude of that relationship. On the other hand, because work-related physical activity was negatively associated with mental status, it was not examined as a mediator.

Sobel Test Results

The results from the Sobel tests that examine physical activity as a mediator in the relationship between race/ethnicity and mental status are presented in Table 6.9. The results showed that vigorous activity reduced the magnitude of the relationships between being black or Hispanic and mental status score ($p<0.0001$). Comparing Tables 6.6 and 6.10 facilitates the interpretation of the mediating relationship. The regression coefficients for black and Hispanic race/ethnicity (Table 6.6) decrease slightly in the presence of vigorous physical activity variable (Table 6.10) indicating that partial mediation has occurred.

Although simple mediation occurred with vigorous activity, similarly to memory, the Sobel tests were calculated with coefficients and standard errors that were adjusted for education. In these calculations, mediation did not occur in the relationships among race/ethnicity, vigorous activity, and mental status.

Table 6.9. Results of Sobel Tests of the mediating effect of physical activity in the relationship between race/ethnicity and mental status in late middle aged adults from the Health and Retirement Study (1996).

	Vigorous Activity
Hispanic	z=-2.61 (p<0.01)
Black	z=-2.76 (p<0.01)

Table 6.10. Results of multivariable regression analyses of the relationships among race/ethnicity, vigorous physical activity, and mental status score (range 0-10) in late middle aged adults from the Health and Retirement Study (1996) (n=7944)

		(SE)
Hispanic	-0.744	0.06 ***
Black	-0.758	0.05 ***
Vigorous Activity	0.062	0.02 **

Summary

In general, the results suggested that different types of leisure time physical activity significantly mediated the relationship between race/ethnicity and both memory and mental status score in the sample used for this research. Mediation requirements were met for light and vigorous activity, and Sobel Tests indicated that partial mediation occurred for both black and Hispanic participants. Although house-related physical activity was positively associated with memory scores at baseline, its presence in the model of the relationship between race/ethnicity and cognitive function enhanced the negative association between black and Hispanic race/ethnicity and memory score.

However, in more complex tests of mediation that adjusted for education level, differential findings arose. Leisure time physical activity did not mediate the relationship between Hispanic ethnicity and memory or either racial/ethnic group and mental status.

The primary explanation for the differential findings is that leisure-time physical activity can be confounded by level of education (Crespo et al., 1999). However, as reviewed in Chapter 3, education can not always explain leisure time physical activity participation (Crespo et al., 2000). Another explanation for this finding may be that the measurement of vigorous activity may not have been as accurate as in Wave I because the dichotomous variable did not allow for a variety of responses. Baron and Kenny report that in the case of measurement error of the mediator, the effect of the potential mediator can be underestimated (1986). The results do, however, support the closer examination of the mediating effects of education that follow.

Race/Ethnicity, Education, and Memory

Bivariable Results

As mentioned previously, education has been shown to be a mediator between race/ethnicity and cognitive function in previous research (Sachs-Ericsson & Blazer, 2005). Because this variable is a critical factor in the cognitive function literature, it was important to establish that the relationships also existed in the sample used for the study. Tables 5.17 and 5.18 showed the results of correlations among race/ethnicity, education (number of years in school), and cognitive function. In Table 5.17, being white was positively correlated with years in school, whereas being Black or Hispanic was negatively correlated with number of years in school ($p<0.0001$). Additionally, similar results are apparent in Table 5.18, for those who worked for pay. Furthermore, education was positively correlated with both memory score and mental status ($p<0.0001$), and figures 6.7 and 6.8 show the bivariable relationships between education and memory and mental status. The preliminary results indicated that the variables of interest met the requirements to test for mediation.

Figure 6.7 Mean memory (unstandardized) scores by education categories in a sample (n=9204) of late middle aged adults in the Health and Retirement Study (1992).

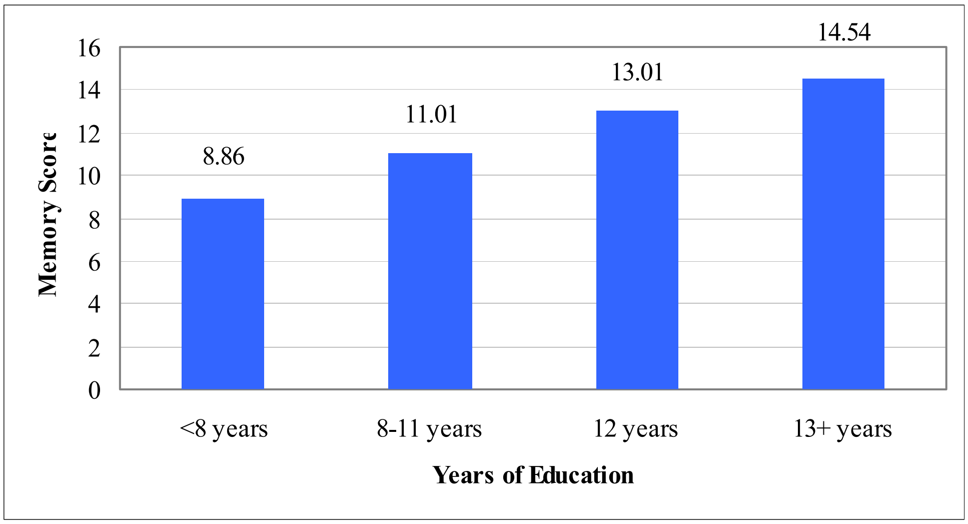
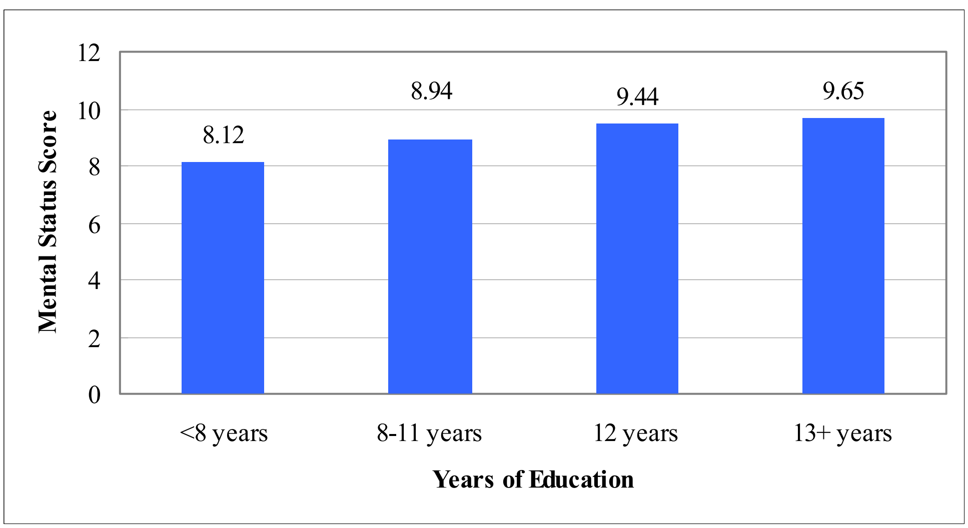


Figure 6.8 Mean mental status scores by education categories in a sample (n=5987) of late middle aged adults in the Health and Retirement Study (1992) who reported working for pay.



Regression Analyses Results

Table 6.1 shows the relationships between race/ethnicity and memory in the total sample and in those who worked for pay. Being black or Hispanic was significantly negatively associated with memory score in 1992 ($p<0.0001$). When race/ethnicity was used to predict years of education, similar results were found. For the total sample and for those who worked for pay, black and Hispanic respondents had significantly fewer years of education than those who were white (see Table 6.11). In the sample and the subsample of those who worked for pay, education was significantly positively associated with memory ($p<0.0001$) as shown in Table 6.12.

Sobel Test Results

Table 6.13 shows that in both the total sample and those who worked for pay, once adjusted for education, the magnitude of the relationship between race/ethnicity and memory decreased ($p<0.0001$). In order to observe the decrease in the relationships, the coefficients from Table 6.14 can be compared to those in Table 6.1. Table 6.1 shows the relationship between race/ethnicity and memory, and Table 6.14 shows those relationships adjusted for education. It is interesting to note that the relationship between being Hispanic and memory for those who work is almost completely mediated by education as seen in Table 6.14b.

Table 6.11: Results of multivariable regression analyses of the relationship between race/ethnicity and education (range 0-17) in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Hispanic	-3.98	0.17	***
Black	-1.30	0.09	***

B. Working Subsample (n=5987)

		(SE)	
Hispanic	-3.38	0.22	***
Black	-1.22	0.12	***

Table 6.12. Results of multivariable regression analyses of the relationship between education (range 0-17) and memory score in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Education	0.10	0.004	***

B. Working Subsample (n=5987)

		(SE)	
Education	0.10	0.01	***

Table 6.13. Results of Sobel Tests of the mediating effect of education in the relationship between race/ethnicity and memory in late middle aged adults from the Health and Retirement Study (1992).

	Education	Education (working)
Hispanic	z=-16.59 (p<0.0001)	z=-12 (p<0.0001)
Black	z=-9.44 (p<0.0001)	z=-8.98 (p<0.0001)

Table 6.14. Results of multivariable regression analyses of the relationships among race/ethnicity, education, and memory score in late middle aged adults from the Health and Retirement Study (1992). Presenting unstandardized beta estimates.

A. Total Sample (n=9204)

		(SE)	
Hispanic	-0.178	0.04	***
Black	-0.529	0.03	***
Education	0.093	0.004	***

B. Working Subsample (n=5987)

		(SE)	
Hispanic	-0.118	0.06	*
Black	-0.460	0.04	***
Eduction	0.096	0.005	***

Race/Ethnicity, Education, and Mental Status

Regression Analyses Results

In order to assess if education also mediated the relationship between race/ethnicity and mental status, regression analyses and Sobel tests were performed again. As mentioned previously, the initial association between race/ethnicity and mental status seen in Table 6.6 indicated that black and Hispanic adults had lower scores on the mental status items than white adults ($p<0.0001$). The relationships were maintained in the subsample of those who worked for pay. The remaining relationships to be assessed were that of race/ethnicity and education in 1996 and education and mental status score. Table 6.15 shows that, similarly to 1992, black and Hispanic participants who were interviewed in 1996 had less years of schooling than their white counterparts ($p<0.0001$). In addition, for participants in 1996, education was significantly positively associated with mental status score ($p<0.0001$) for the whole sample and those who worked, as seen in Table 6.16.

Sobel Test Results

Sobel tests results can be found in Table 6.17. For both the total sample and those who worked for pay, education was a significant mediator of the relationship between race/ethnicity and mental status in 1996 ($p<0.0001$). Comparing the results from Table 6.15 to 6.18 facilitates the interpretation of the mediating effects. The magnitude of the relationship between black and Hispanic race/ethnicity and mental status score (Table 6.15) decreases when adjusted for education (Table 6.18).

Table 6.15: Results of multivariable regression analyses of the relationship between race/ethnicity and education (range 0-17) in late middle aged adults from the Health and Retirement Study (1996). Presenting unstandardized beta estimates.

A. Total Sample (n=7944)

		(SE)	
Hispanic	-3.96	0.18	***
Black	-1.36	0.10	***

B. Working Subsample (n=4219)

		(SE)	
Hispanic	-3.23	0.23	***
Black	-1.26	0.13	***

Table 6.16. Results of multivariable regression analyses of the relationship between education (range 0-17) and mental status (range 0-10) in late middle aged adults from the Health and Retirement Study (1996).

A. Total Sample (n=7944)

		(SE)	
Education	0.12	0.004	***

B. Working Subsample (n=4219)

		(SE)	
Education	0.09	0.01	***

Table 6.17. Results of Sobel Tests of the mediating effect of education in the relationship between race/ethnicity and mental status in late middle aged adults from the Health and Retirement Study (1996).

	Education	Education (working)
Hispanic	z=-14.96 (p<0.0001)	z=-7.02 (p<0.0001)
Black	z=-11.32 (p<0.0001)	z=-6.22 (p<0.0001)

Table 6.18. Results of multivariable regression analyses of the relationships among race/ethnicity, education, and mental status score (range 0-10) in late middle aged adults from the Health and Retirement Study (1996).

A. Total Sample (n=7944)

		(SE)
Hispanic	-0.348	0.05 ***
Black	-0.626	0.04 ***
Education	0.102	0.005 ***

B. Working Subsample (n=4219)

		(SE)
Hispanic	-0.231	0.06 **
Black	-0.441	0.05 ***
Education	0.081	0.01 ***

Summary

The results suggest that education partially mediates the relationship between race/ethnicity and cognitive function in the sample of HRS participants. For both black and Hispanic adults, the magnitude of the negative relationships with both memory and mental status declined when adjusted for years of schooling.

SPECIFIC AIM II RESULTS

The purposes of Specific Aim II were to investigate the cross-sectional mediating effects of both physical activity and education in the relationship between race/ethnicity and memory and mental status scores in late middle aged adults using the Health and Retirement Study participants. Results of regression analyses and statistical tests of mediation, Sobel tests, indicated that vigorous and light activity partially mediated the relationship between race/ethnicity and memory/mental status. Furthermore, housework activity may contribute to the negative relationship between race/ethnicity and physical activity. Finally, results suggested that education partially mediated the relationship between race/ethnicity and mental status.

Chapter 7: Specific Aim III Results

The goals of Specific Aim III were (1) to examine the longitudinal relationship between ethnicity, physical activity, education and cognitive function, and (2) to determine if there were differential effects of education level, physical activity level, or racial/ethnic group on rates of decline in cognitive function. The hypothesis for Specific Aim III was that more years of education and increased physical activity would both be associated with greater preservation of cognitive function over a 7 year period. Due to the positive associations between physical activity/education and cognitive function found at baseline, the expectation was that both physical activity and education would be protective of cognitive function over time. This chapter presents the relationships between race/ethnicity and changes in cognitive function. In addition, the relationships among years of education, physical activity, and changes in memory and mental status are discussed.

RESULTS

Race/Ethnicity and Cognitive Function

One of the main goals of the longitudinal analyses was to contribute to the literature about differences in rates of change of cognitive function scores by ethnicity. As stated previously, results from prior studies examining the link between race/ethnicity and cognitive function over time yield mixed conclusions. Therefore, exploratory analyses of memory and mental status changes over time were conducted in the context of race/ethnicity.

Memory

Table 7.1 shows the relationships between race/ethnicity and memory score in 1996. Results (Model 1) indicate being Hispanic was not significantly associated with memory score compared to whites ($p=0.27$). However, being black was associated with lower memory scores than being white ($p<0.0001$). Due to this finding, further longitudinal effects of race/ethnicity on memory decline were explored. The interaction term between ethnicity and time (see Model 3) showed that there were no significant differences in decline rates of memory scores by Hispanic or black race/ethnicity ($p=0.30$ and 0.60, respectively). Figure 7.1 shows the difference in mean memory score over time by race adjusted for demographic, health-related, and social variables. Although being black was associated with lower memory scores than being white, rates of change were not different among the three racial/ethnic groups. In the subsample of those who worked, almost identical relationships between race/ethnicity and memory score were found (Table 7.2).

Mental Status

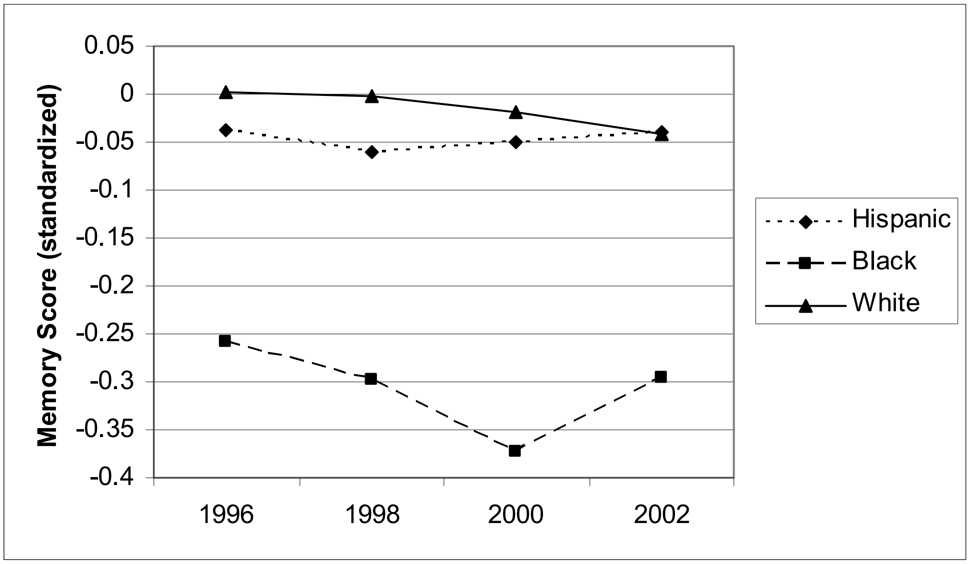
Although an average increase in mental status score of 0.02 points occurred at each survey wave, race/ethnicity was negatively associated with mental status score in longitudinal mixed models that were adjusted for demographic, health-related, and social variables (Table 7.3, Model 1). When compared to white participants, Hispanic participants had mental status scores that were 0.28 points lower, and being black was associated with a -0.56 unit difference in mental status scores ($p<0.0001$). In order to determine if there were racial/ethnic effects on rates of mental status score changes over time, the interaction term between ethnicity and time was added to the model. Similarly to memory score, the interaction term was insignificant. The results in Model 3 show that there were no significant differences in rates of change over time by racial/ethnic group. A visual interpretation of mean mental status scores by race/ethnicity over time can be found in Figure 7.2. The same cross-sectional results were found in the smaller sample of those who worked (Table 7.4, Model 1), and there were no significant differences in the rate of change in mental status score by race/ethnicity (Model 3). Following the examination of race/ethnicity and cognitive function, the roles of education and physical activity in cognitive function over time were explored.

Table 7.1. Results of longitudinal mixed models of relationships among race/ethnicity, physical activity, education, memory, and time in late middle aged adults (n=7944) in the Health and Retirement Study (1996-2002). Presenting unstandardized beta estimates.

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)
Intercept	0.44	0.17 *	0.42	0.17 *	0.44	0.17 *	0.44	0.17 *
Time	-0.01	0.004 **	0.005	0.02	-0.01	0.004 **	-0.01	0.01
Hispanic	-0.04	0.03	-0.04	0.03	-0.05	0.04	-0.04	0.03
Black	-0.29	0.02 ***	-0.29	0.02 ***	-0.29	0.03 ***	-0.29	0.02 ***
Age	-0.02	0.003 ***	-0.02	0.003 ***	-0.02	0.003 ***	-0.02	0.003 ***
Male	-0.43	0.02 ***	-0.43	0.02 ***	-0.43	0.02 ***	-0.43	0.02 ***
Income Q1	-0.21	0.03 ***	-0.21	0.03 ***	-0.21	0.03 ***	-0.21	0.03 ***
Income Q2	-0.12	0.03 ***	-0.12	0.03 ***	-0.12	0.03 ***	-0.12	0.03 ***
Income Q3	-0.08	0.02 **	-0.08	0.02 **	-0.08	0.02 **	-0.08	0.02 **
Education	0.09	0.003 ***	0.09	0.00 ***	0.09	0.003 ***	0.09	0.003 ***
Not married	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.02
Not working	-0.05	0.02 *	-0.05	0.02 *	-0.05	0.02 *	-0.05	0.02 *
Self rated health	0.002	0.000 ***	0.002	0.000 ***	0.002	0.0004 ***	0.002	0.0004 ***
Chronic Illness	-0.03	0.01 **	-0.03	0.01 **	-0.03	0.01 **	-0.03	0.01 **
Underweight	-0.06	0.08	-0.06	0.08	-0.06	0.08	-0.06	0.08
Overweight	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.02	0.02
Obese	-0.01	0.02	-0.01	0.02	-0.01	0.02	-0.01	0.02
CESD	-0.03	0.01 ***	-0.03	0.01 ***	-0.03	0.01 ***	-0.03	0.01 ***
Church Attendance	0.01	0.01 *	0.01	0.01 *	0.01	0.01 *	0.01	0.01 *
Less Vigorous Activity	-0.03	0.01 *	-0.03	0.01 *	-0.03	0.01 *	-0.01	0.02
Time * Education			-0.002	0.001				
Time * Hispanic					0.01	0.01		
Time * Black					-0.01	0.01		
Time * Less Vigorous Activity							-0.01	0.01

Notes:
* p<0.05
** p<0.001
*** p<0.0001

Figure 7.1. Plot of average standardized memory scores over time for white, black, and Hispanic adults in the Health and Retirement Study between 1996-2002.



Notes: Means adjusted for race/ethnicity, age, sex, household income, working status, marital status, self-rated health, chronic illnesses, BMI, CESD, physical activity, and church attendance

Education and Cognitive Function

Memory - Total Sample

Longitudinal mixed models were used to examine the relationship between education and memory in models adjusted for demographic, social, and health-related covariates (see Table 7.1). Model 1 shows the relationship between education and memory at each wave, and Model 2 shows memory score decline with each additional year of education as indicated by the interaction term.

In the study sample, the memory score declined an average of 0.01 units every other year of the survey (Model 1). Each year of education was associated with an additional 0.09 units of memory score ($p<0.0001$). In order to determine if education level influenced memory score change over time, an interaction term was added to Model 1 (see Model 2). The results suggested that, although education was associated with higher memory scores across time, those with higher levels of education did not decline at a faster or slower rate than those with lower levels (p=0.22). A further exploration of interaction effects with time to determine if certain thresholds of education were associated with differential rates of memory decline revealed similar results. Using the education categories from previous cross-sectional analyses (<8 years, 8-11 years, 12 years, 13 or more years), the results remained unchanged. However, after comparing mean memory test scores by education level (adjusted for model covariates), mean memory scores for those with greater than 8 years of education were significantly higher than those with less than 8 years of education. Thus, the interaction term between time and less than or greater than 8 years of education was examined, but the results remained unchanged.

Memory - Working Subsample

In identical analyses for those who were working for pay in 1996 (n=4219), the results were slightly different. Table 7.2 (Model 1) shows that over time, the average memory score for those who worked remained unchanged (p=0.45). For each additional year of education, memory scores were an average of 0.08 units higher (p<0.0001) (Model 1). However, similar to the total sample, education did not impact the change in memory score over time as depicted in Model 2 (p=0.35).

Mental Status – Total Sample

Following the analysis of memory score, longitudinal mixed models were used to determine the relationship between education and mental status score. These analyses were applied only to those 63 and older in 1996 (n=1916) because mental status questions were asked only of those aged 65 and older in 1998, 2000, and 2002. After adjusting for demographic, health-related, and social covariates, the relationships found were similar to that of education and memory in Tables 7.1 and 7.2. Table 7.3 shows the relationships between time and mental status score, education and mental status score, and the interaction between education and time and mental status score. On average, respondents' mental status scores did not decline; the scores increased by 0.02 points per survey year (p=0.01) (Model 1). Though this increase was statistically significant, whether or not it is meaningful is debatable. A similar result was addressed in a study by Rodgers and colleagues who used both HRS and AHEAD data to explore the potential learning or practice effects with respect to the cognitive function measures (2003). They argued that the improvement over time was negligible and that respondents learn answers to questions that are repeatedly asked in longitudinal surveys. Furthermore, Ofstedal and colleagues report that much of the improvement seems to be from respondents remembering the answers to the naming questions (scissors and cactus) (2005). This is a study limitation that will be discussed in the limitations section.

For each additional year of schooling, mental status scores at each wave were 0.08 points higher (p<0.0001) (Model 1). In order to examine the effect of level of education on rate of mental status score change over time, the interaction term was tested (see Model 2, Table 7.3). Levels of education were not differentially related to rates of mental status score change over time (p=0.36). Education categories were also interacted with time to determine if certain educational thresholds were associated with rates of change in scores, and the results remained unchanged.

Mental Status - Working Subsample

The relationships between education and mental status score were similar when the analyses were restricted to those who were working for pay in 1996. Table 7.4 (Model 1) shows that mental status score did not increase or decrease over time;

however, more education was associated with higher mental status scores ($p<0.0001$). The positive relationship did not extend to rates of change (see Model 2).

Table 7.2. Results of longitudinal mixed models of relationships among race/ethnicity, physical activity, education, memory, and time in late middle aged adults who worked for pay in 1996 (n=4219) from the Health and Retirement Study (1996-2002). Presenting unstandardized beta estimates.

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)
Intercept	0.97	0.27 **	1.00	0.27 **	0.97	0.27 **	0.97	0.27 **	0.96	0.27 **
Time	-0.01	0.01	-0.03	0.03	-0.01	0.01	-0.003	0.01	0.0002	0.01
Hispanic	-0.03	0.05	-0.03	0.05	-0.06	0.06	-0.03	0.05	-0.03	0.05
Black	-0.25	0.04 ***	-0.25	0.04 ***	-0.25	0.04 ***	-0.25	0.04 ***	-0.25	0.04 ***
Age	-0.03	0.00 ***	-0.03	0.00 ***	-0.03	0.00 ***	-0.03	0.00 ***	-0.03	0.00 ***
Male	-0.43	0.03 ***	-0.43	0.03 ***	-0.43	0.03 ***	-0.43	0.03 ***	-0.43	0.03 ***
Income Q1	-0.18	0.05 **	-0.18	0.05 **	-0.18	0.05 **	-0.18	0.05 **	-0.18	0.05 **
Income Q2	-0.14	0.04 **	-0.14	0.04 **	-0.14	0.04 **	-0.14	0.04 **	-0.14	0.04 **
Income Q3	-0.12	0.03 **	-0.12	0.03 **	-0.12	0.03 **	-0.12	0.03 **	-0.12	0.03 **
Education	0.08	0.01 ***	0.08	0.01 ***	0.08	0.01 ***	0.08	0.01 ***	0.08	0.01 ***
Not married	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.03	0.04	0.03
Self rated health	0.002	0.001 *	0.002	0.001 *	0.002	0.001 *	0.002	0.001 *	0.002	0.001 *
Chronic Illness	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01	0.01
Underweight	-0.05	0.14	-0.05	0.14	-0.05	0.14	-0.05	0.14	-0.05	0.14
Overweight	-0.02	0.04	-0.02	0.04	-0.02	0.04	-0.02	0.04	-0.02	0.04
Obese	-0.01	0.03	-0.01	0.03	-0.01	0.03	-0.01	0.03	-0.01	0.03
CESD	-0.04	0.01 ***	-0.04	0.01 ***	-0.04	0.01 ***	-0.04	0.01 ***	-0.04	0.01 ***
Church Attendance	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Less Vigorous Activity	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.02	0.03	-0.03	0.02
Work Activity	-0.05	0.01 ***	-0.05	0.01 ***	-0.05	0.01 ***	-0.05	0.01 ***	-0.04	0.01 *
Time * Education			0.002	0.002						
Time * Hispanic					0.03	0.03				
Time * Black					0.004	0.02				
Time * Less Vigorous Activity							0.00	0.01		
Time * Work Physical Activity									0.00	0.01

Notes:
* p<0.05
** p<0.001
*** p<0.0001

Physical Activity and Cognitive Function

Memory-Total Sample

In longitudinal models of memory score, vigorous physical activity was significantly positively associated with memory. Therefore, it was hypothesized that activity may help prevent decline. As shown in Table 7.1, using longitudinal mixed models, those who reported engaging in vigorous physical activity less than 3 times per week or more had memory scores that were 0.03 points lower at each wave than those who reported engaging in vigorous physical activity 3 times per week or more, even after adjusting for demographic, health-related, and social covariates (p=0.02). However, physical activity levels did not differentially impact the slope of memory decline over time (p=0.22) (see Model 4).

Table 7.3. Results of longitudinal mixed models of the relationships among race/ethnicity, physical activity, education, mental status, and time in adults aged 63+ in 1996 (n=1916) in the Health and Retirement Study (1996-2002). Presenting unstandardized beta estimates.

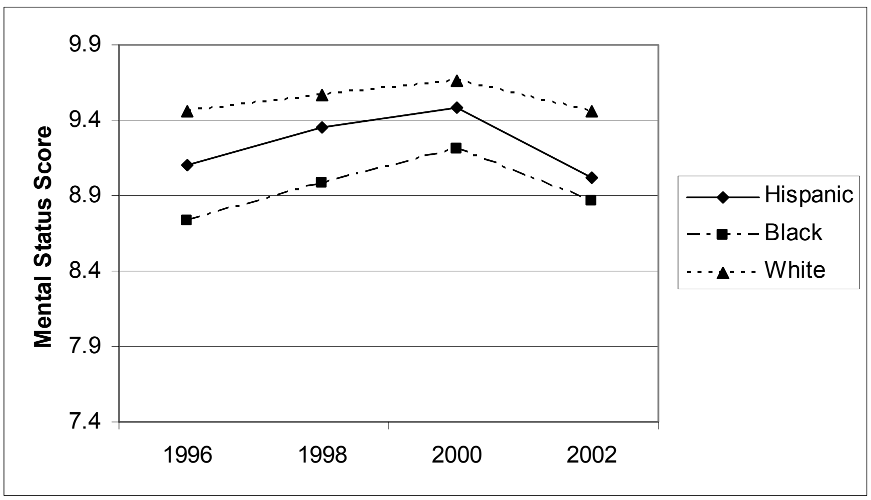
	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)
Intercept	9.05	1.24 ***	8.97	1.24 ***	9.05	1.24 ***	9.03	1.24 ***
Time	0.02	0.01 **	0.05	0.03 **	0.02	0.01 **	0.04	0.01 **
Hispanic	-0.28	0.06 ***	-0.28	0.06 ***	-0.29	0.09 ***	-0.28	0.06 ***
Black	-0.56	0.05 ***	-0.56	0.05 ***	-0.64	0.07 ***	-0.56	0.05 ***
Age	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.02	0.02
Male	-0.07	0.03 *	-0.07	0.03 *	-0.07	0.03 *	-0.07	0.03 *
Income Q1	-0.09	0.06	-0.09	0.06	-0.09	0.06	-0.09	0.06
Income Q2	0.09	0.05	0.09	0.05	0.09	0.05	0.09	0.05
Income Q3	0.09	0.05	0.09	0.05	0.09	0.05	0.09	0.05
Education	0.08	0.01 ***	0.08	0.01 ***	0.08	0.01 ***	0.08	0.01 ***
Not married	-0.03	0.04	-0.03	0.04	-0.03	0.04	-0.03	0.04
Not working	-0.01	0.04	-0.005	0.04	-0.005	0.04	-0.01	0.04
Self Rated Health	0.002	0.001 *	0.002	0.001 *	0.002	0.001 *	0.002	0.001 *
Chronic Illness	-0.002	0.01	-0.002	0.01	-0.001	0.01	-0.001	0.01
Underweight	-0.09	0.17	-0.09	0.17	-0.09	0.17	-0.09	0.17
Overweight	-0.04	0.04	-0.04	0.04	-0.04	0.04	-0.04	0.04
Obese	-0.03	0.04	-0.03	0.04	-0.03	0.04	-0.03	0.04
CESD	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01	0.01
Church Attendance	-0.02	0.01	-0.02	0.01	-0.02	0.01	-0.02	0.01
Less Vigorous Activity	-0.02	0.02	-0.02	0.02	-0.02	0.02	0.03	0.05
Time * Education			-0.002	0.003				
Time * Hispanic					0.002	0.03		
Time * Black					0.03	0.02		
Time * Less Vigorous Activity							-0.02	0.02

Notes:
* p<0.05
** p<0.001
*** p<0.0001

Memory - Working Subsample

Physical activity and memory score were again assessed in longitudinal models using data from those who reported working for pay in 1996. Results can be seen in Table 7.2. As mentioned previously, memory score did not significantly decrease over time. In addition, each additional level of work physical activity was associated with 0.05 fewer points on the memory score (p<0.0001) (Model 1). In order to determine if level of work-related physical activity affected rates of memory score change over time, the interaction between time and work activity was tested. No association was found between work physical activity levels and change in memory score over time as shown in Model 5 (p=0.46).

Figure 7.2. Plot of average mental status scores over time for white, black, and Hispanic adults in the Health and Retirement Study between 1996-2002.



Notes: Means adjusted for race/ethnicity, age, sex, household income, working status, marital status, self-rated health, chronic illnesses, BMI, CESD, physical activity, and church attendance

Mental Status - Total Sample

Longitudinal mixed models were used to determine the effects of physical activity on mental status score over time (see Table 7.3). As stated previously, in the sample of those 65 and older, mental status scores increased an average of 0.02 points at each survey year. Similar to cross-sectional results from Aim I, vigorous physical activity was not associated with mental status score (p=0.39) (Model 1). Furthermore, different levels of vigorous physical activity were not associated differentially with mental status score change (see Model 4) after adjusting for demographic, health-related, and social covariates (p=0.23).

Table 7.4. Results of longitudinal mixed models of the relationships among race/ethnicity, physical activity, education, mental status, and time in adults aged 63+ and working for pay in 1996 (n=633) in the Health and Retirement Study (1996-2002). Presenting unstandardized beta estimates.

	Model 1	(SE)	Model 2	(SE)	Model 3	(SE)	Model 4	(SE)	Model 5	(SE)
Intercept	9.82	2.23 ***	9.83	2.24 ***	9.86	2.23 ***	9.78	2.23 ***	9.82	2.23 ***
Time	0.04	0.02 *	0.03	0.08	0.02	0.02	0.05	0.03 **	0.03	0.03
Hispanic	-0.29	0.12 *	-0.29	0.12 *	-0.42	0.21 *	-0.29	0.12 *	-0.29	0.12 *
Black	-0.42	0.08 ***	-0.42	0.08 ***	-0.59	0.14 ***	-0.41	0.08 ***	-0.42	0.08 ***
Age	-0.04	0.04	-0.04	0.04	-0.04	0.04	-0.04	0.04	-0.04	0.04
Male	-0.08	0.06	-0.08	0.06	-0.08	0.06	-0.08	0.06	-0.08	0.06
Income Q1	-0.17	0.11	-0.17	0.11	-0.17	0.11	-0.17	0.11	-0.17	0.11
Income Q2	0.02	0.08	0.02	0.08	0.02	0.08	0.02	0.08	0.01	0.08
Income Q3	-0.003	0.08	-0.003	0.08	-0.01	0.08	-0.001	0.08	-0.004	0.08
Education	0.06	0.01 ***	0.06	0.02 ***	0.06	0.01 ***	0.06	0.01 ***	0.06	0.01 ***
Not married	-0.01	0.07	-0.01	0.07	-0.002	0.07	-0.01	0.07	-0.01	0.07
Self Rated Health	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002	0.003	0.002
Chronic Illness	0.02	0.03	0.02	0.03	0.03	0.03	0.02	0.03	0.02	0.03
Underweight	0.38	0.40	0.38	0.40	0.37	0.40	0.38	0.40	0.38	0.40
Overweight	0.07	0.08	0.07	0.08	0.07	0.08	0.07	0.08	0.07	0.08
Obese	0.12	0.07	0.12	0.07	0.12	0.07	0.12	0.07	0.12	0.07
CESD	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Church Attendance	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03	0.02
Less Vigorous Activity	0.01	0.05	0.01	0.05	0.01	0.05	0.10	0.10	0.01	0.05
Work Physical Activity	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.03	0.04
Time * Education			0.0004	0.01						
Time * Hispanic					0.06	0.08				
Time * Black					0.08	0.05				
Time * Less Vigorous Activity							-0.04	0.04		
Time * Work Physical Activity									0.01	0.02

Notes:
* p<0.05
** p<0.001
*** p<0.0001

Mental Status - Working Subsample

In the sample of those who reported working for pay in 1996 and who were also 63 years or older, mental status score increased an average of 0.04 points per wave (see Table 7.4). In addition, work physical activity was not associated with mental status test performance after adjusting for demographic, health-related, and social variables (p=0.49) (Model 1). Furthermore, when work physical activity levels were examined as possible predictors of rate of mental status change over time, results suggested that there were no associations ($p=0.67$).

SPECIFIC AIM III SUMMARY

The purpose of Specific Aim III was to determine if education and/or physical activity were protective of cognitive decline, and to determine if there were racial/ethnic differences in cognitive decline. Results indicated that although being white or Hispanic, increased education, increased vigorous activity, and less work-related physical activity were associated with higher memory scores at each wave, none impacted rates of change in memory score over time.

With regard to mental status scores, the results showed that being white and increased education were positively related to mental status scores. However, no variables of interest were associated with differential rates of change.

Chapter 8: Discussion

INTRODUCTION

In this sample of late middle aged adults, disparities in memory and mental status scores by race ethnicity were present throughout the course of the study (Aims I and III), however rates of change in scores did not differ by racial/ethnic group (Aim III). In addition, education, and in some cases, leisure time physical activity were mediators of the relationship between race/ethnicity and cognitive function (Aim II), and were associated with cognitive function across time, but did not impact rates of change in cognitive function scores (Aim III). The findings that disparities in cognitive function occur as early as late middle age and extend into older ages, but do not worsen over time are a significant contribution to the current literature about race/ethnicity and cognitive function.

AIM I: DIFFERENCES IN COGNITIVE FUNCTION BY RACIAL/ETHNIC GROUP

Findings

Ordinary least squares regression analyses were used to determine if there were racial/ethnic differences in memory or mental status scores among black, Hispanic, and white adults in late middle age. Models adjusted for demographic, health-related, and social covariates, and the results showed that being black or Hispanic was associated with significantly lower memory scores than being white. With regard to mental status, being black or Hispanic was also associated with lower scores than being white. However, in the subsample of those who reported working for pay in 1992 and 1996, there were no differences in mental status scores between Hispanic and white participants.

Comparison to Previous Research

Many studies have identified relationships between race/ethnicity and cognitive function in older adults, but have rarely examined cognitive disparities in late middle age. This is important because if disparities that have been observed at older ages are found in younger age groups, attempts to address the disparities can be expanded.

With few exceptions, research has shown that among older aged persons, black and Hispanic adults have lower scores on tests of cognitive function than their white counterparts, even when adjusting for socioeconomic status (Proctor et al., 1997; Kuller et al., 1998; Stump et al., 2001; Zsembik & Peek, 2001; Lopez et al., 2003; Rodgers et al., 2003; Schwartz et al., 2004; Sloan & Wang, 2005; Wright et al., 2004). The findings from the current study, that there are race/ethnic differences in memory and mental status scores, were consistent with those in previous research. The finding that sociodemographic measures, particularly education, influence the relationship between Hispanic ethnicity and mental status score, such that a disparity no longer exists, is also in line with current research. In a study using data from the HRS and AHEAD where there were no differences in odds of obtaining a low total cognitive score between Hispanic and white elders aged 70 and older once education was included in multivariable models (Rodgers et al., 2003). The finding was also consistent with research on a larger sample of participants in the HRS using slightly different outcome measures from the present study. Differences in scores existed among the three racial/ethnic groups, but the differences between Hispanics and whites were not as substantial as the differences between blacks and whites (Sloan & Wang, 2005).

The finding that Hispanic ethnicity was no longer associated with mental status scores in the subsample of those who reported working for pay was not expected. The benefits of paid work on cognitive status are not well documented, but working may be related to the types of cognitive activities (e.g. reading) that have been associated with higher cognitive test scores (Wilson et al., 1999). Perhaps Hispanic participants on average had more cognitively stimulating jobs than black participants. Or, it is possible that the stereotype threat that has been shown to impede cognitive test performance among blacks was present. This is discussed further in the next section. In the current study, because work status was associated with higher cognitive function scores in cross-sectional and baseline longitudinal models, analyses were performed to determine if working was protective of cognitive decline and the relationship was found to be insignificant. More research about employment type and its effect on cognitive function should be conducted.

Interpretation of the Findings

Minority participants generally had lower scores on cognitive function measures than white participants even when adjusting for socioeconomic status and other correlates of cognitive function. This finding indicates that racial/ethnic disparities in cognitive function begin earlier in life, and more research should be done to determine if these differences are preventable or modifiable. In addition, one goal of multivariable modeling was to help explain the potential disparities with the understanding that race is a social construct, and model covariates did not fully accomplish that goal. There are additional possible explanations for the unexplained variance in the relationships. Specifically, wealth, quality of education, literacy and perceived racism were not included in the analyses and may have changed the results.

Wealth and Income

It has been suggested that household income and years of education are not necessarily adequate measures of socioeconomic status or sufficient to balance the socioeconomic disparities that affect cognitive function (Manly, 2006). Income does not take into account how much money is leaving a household to go to other family members, or how much remains after house payments, bills, and other expenses are considered (Conley, 1999). For example, black or Hispanic persons may have larger families than white persons (U.S. Census Bureau, 2006) and the same amount of income may not be spent in the same ways. Therefore, when those in a smaller family may be able spend money on cognitive enhancing activities such as organized sports or museum attendance, those from a larger family with the exact same household income may not have that luxury. The Health and Retirement Study includes one of the most comprehensive measures of household income, incorporating all types of potential income in addition to salary, however the measure may not have been a sufficient proxy for wealth or financial burden. Besides wealth, other variables that detect socioeconomic disparities may be of importance. For example, using data from the Baltimore Memory Study, Schwartz and colleagues attempted to include a socioeconomic instrument that accounted for wealth in addition to income (2004). Disparities in cognitive function scores remained between black and white adults; however, even though the instrument was more complex than typical measures of SES, quality of education or literacy were not included (Schwartz et al., 2004).

Quality of Education and Literacy

Though education is an important measure of socioeconomic status, a factor considered a fundamental cause of disease (Link & 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 (Albert &

Teresi, 1999; Manly et al., 2002;). 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 (Gurland et al., 2001; Manly et al., 2002). 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 & 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., 2002).

Quality of education is another concept that may help to explain racial/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; Anderson, 1988). If education is thought to contribute to cognitive function scores by contributing to the development mental strategy skills, such as memorization techniques (Mirowsky & 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 race/ethnicity and cognitive function.

Perceived Racism

Steele and colleagues have suggested that perceived racism or "stereotype threat" may contribute to disparities in scores on tests of cognitive function (Steele & Aronson, 1995; Steele, 1997), and this idea has been cited by a number of researchers as a potential explanation of racial/ethnic differences in cognitive function found in their studies (Osborne, 2001; Zsembik & Peek, 2001; Manly, 2006). The ideas behind the concept have been applied specifically to black/white disparities in cognitive function. Some research has shown that black adults, 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 & Aronson, 1995; Steele, 1997; McKay, 2003). As mentioned previously, this may be a potential explanation for the finding that, among those who work, disparities in mental status scores existed only between black and white participants. It may be that black adults in the workplace are more exposed to stereotyping and racism and are more likely to succumb to stereotype threat on tests of cognitive function. This pressure can be alleviated by referring to measures in less threatening ways, such as using the words "challenge," or "problem solving task," rather than the word "ability" (Steele & Aronson, 1995; Steele, 1997).

In the HRS, at the beginning of the section of cognitive function measures, the first question is stated, "Part of this study is concerned with people's memory, and ability to think about things. First, how would you rate your ability to think quickly at the present time?" It is possible that the choice of the word "ability" contributed to stereotype threat. One way to address this is to include in studies a scale that measures an individual's level of perceived racism, such as the "Everyday Discrimination Scale," and to adjust for this in multivariable models (Williams et al., 1997). In the HRS, no measures of perceived discrimination were included and this is a significant limitation of the study.

AIM II: MEDIATING EFFECTS OF PHYSICAL ACTIVITY AND EDUCATION IN THE RELATIONSHIP BETWEEN COGNITIVE FUNCTION AND RACE/ETHNICITY

Findings

In cross-sectional analyses from Aim I, when demographic covariates, such as education, were entered into the models, the magnitude of the relationship between race/ethnicity and cognitive function decreased. In addition, education and, in several cases, physical activities were positively associated with cognitive function score regardless of racial/ethnic group. Therefore, the purpose of Specific Aim II was to formally investigate the cross-sectional mediating capabilities of both physical activity and education in the relationship between race/ethnicity and memory and/or mental status in late middle aged adults.

Physical Activity

Among different types of physical activity, results indicated that light and vigorous leisure time physical activity partially mediated the relationship between being black and memory score. Although housework activity was positively associated with memory scores in the analyses, its presence in the multivariable model strengthened the negative relationship between Hispanic ethnicity and physical activity. Finally, work physical activity was negatively associated with both memory and mental status score.

Education

Furthermore, education partially mediated the relationship between race/ethnicity and both memory and mental status for both Hispanic and black participants. These results are exemplified when examining multi-level model tables from Specific Aim I (see Tables 5.8-5.11), where the magnitude of the relationships between race/ethnicity and cognitive function drops from Models 1 to 2 after education and other demographic variables adjust the relationships. And, in the sample of those who worked for pay, the relationship between Hispanic race/ethnicity and cognitive function became no different than that of whites after education and sociodemographic measures were added.

Comparison to Previous Research

Physical Activity

As stated previously, physical activity is not usually studied as a potential mediator between race/ethnicity and cognitive function. However, because it has been shown to be a correlate of cognitive outcome, it is important to include it as a measure in studies of cognitive function. Using the MacArthur Studies of Successful Aging, researchers provided justification for further research by finding that when strenuous activity was included in multivariable models, the effect of black race on cognitive decline diminished (Albert et al., 1995). Furthermore, the HRS had several measures in addition to vigorous physical activity such as light activity, housework, and work-related activity, which allowed for a more comprehensive investigation of the relationship. The results of this study were somewhat consistent with Albert and colleagues, in that vigorous physical activity was found to be a mediator between race/ethnicity memory and mental status scores. The results from the current study contribute to the literature by showing that light activity is also associated with cognitive function and has an important mediating role. In addition, house-related physical activity may contribute to an increase in the negative association between Hispanic ethnicity and memory, and this should be explored in future research.

Education

The mediating effect of education between race/ethnicity-cognitive and function was supported in the current research and is consistent with previous research showing that education has a substantial impact on the relationship (Zsembik & Peek, 2001; Sachs-Ericsson & 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 (Scherr et al., 1988; Evans et al., 1993; Albert et al., 1995; Farmer et al, 1995).

Interpretation of Findings

The findings indicated that education, vigorous physical activity, and light physical activity, explain part of the relationship between race/ethnicity and scores on cognitive function tests such as memory and mental status. In most cases, the results were not sufficient to suggest complete mediation, thus, continued research should be conducted to investigate other mediators. However, for Hispanics, but not for black participants, education completely mediated the disparity from whites in mental status scores. It is possible that a Hispanic person who is as socially and economically as disadvantaged as a black person, but has the same level of education, is at an advantage with regard to test performance. Using data from the National Education Longitudinal Study, Goldsmith analyzed the effects of school segregation in the early 1990's on test scores (2003). 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 (Kao & Tienda, 1990; Goldsmith, 2003). In future research, immigrant status should be explored in greater detail in analyses of cognitive function test scores. In addition, the finding that housework activity contributed to the negative relationship between Hispanic ethnicity and memory score should be explored further.

AIM III: LONGITUDINAL RELATIONSHIP AMONG RACE/ETHNICITY, PHYSICAL ACTIVITY, EDUCATION, AND COGNITIVE FUNCTION

Findings

Because physical activity and education were positively associated with memory and mental status scores, the relationships were examined in longitudinal models. The first goal of Specific Aim III was to determine if either physical activity or education was protective of cognitive decline. In addition, a second goal was to investigate changes over time in cognitive function by racial or ethnic group. Longitudinal mixed modeling showed that, in general, physical activity and education, though associated with higher cognitive function scores, were not associated with rates of change over time. Furthermore, racial/ethnic differences in rates of change did not exist.

Comparison to Previous Research

Physical Activity

The results of the analyses are partially consistent with previous research (Sturman et al., 2005). In the case of physical activity, many studies have found that physical activity is positively associated with cognitive function (Albert et al., 1995; Laurin, 2001; Yaffe et al., 2001; Barnes et al., 2003; Abbott et al., 2004; Lytle et al., 2004; Van Gelder et al., 2004; Weuve et al., 2004; Rovio, 2005; Larson et al., 2006; Simons et al., 2006). However, most of these studies include of participants who were all one race/ethnicity or one gender. At least two studies of multiethnic coed samples have explicitly examined physical activity as a predictor of cognitive change (Albert et al., 1995; Sturman et al., 2005). As mentioned previously, researchers from the MacArthur Studies of Successful Aging noted that strenuous physical activity was protective of cognitive change over time in a sample of black and white adults (Albert et al., 1995). Conversely, Sturman and colleagues found in black and white older adults (mean age of 73 years) enrolled in the Chicago Health and Aging Project, physical activity was not protective of cognitive decline when cognitive activities (e.g. reading) were included in multivariable models (2005). Though compelling information, the negative finding warrants further exploration considering that physical activity has been shown to affect cognitive function in an experimental setting (Kramer et al., 1999). In the current project, because decline in memory score was so minimal, and mental status score slightly increased on average, physical activity may not have been related to change due to the lack of variability in scores. When more waves of HRS data have been collected, future research should continue to explore the possibility of an impact of leisure time physical activity on rates of decline of memory scores.

Education

With regard to education, though consistently related to cognitive function in cross sectional studies, research about its effect on decline has produced mixed results. In the National Institute of Mental Health Epidemiologic Catchment Area (ECA) Study, almost 15,000 people were assessed with the MMSE. In those younger than 65 and older than 65, education level was protective against decline in MMSE score for those who started with scores higher than the MMSE cutoff of 23 (Farmer et al., 1995). However, the follow-up time was only one year, and for those with scores of 23 or less, decline was not affected by years of education (Farmer et al., 1995). In a follow-up study, using only the Baltimore participants from the ECA, researchers found that an educational threshold of 8 years was an important predictor of decline in MMSE scores (Lykestos et al., 1999). Those who had less than 8 years of education had greater rates of decline than those with 9 or more (Lykestos et al., 1999).

The conflicting results have presented a challenge to researchers, and most recently, researchers using the AHEAD data attempted to determine if education affected decline (Alley et al., 2007). Researchers divided the cognitive items into four measures: immediate recall, delayed recall, mental status items, and the serial 7 subtraction test. They found that higher education was associated with more rapid decline on the delayed recall measure, but a slower rate of decline on the mental status measure (Alley et al., 2007). The results of this and other studies imply that education may not protect against decline in cognitive function as a whole, but that it may have differential effects of decline by cognitive domain. In the current study, the lack of effect of education on either memory or mental status change may have been due to the minimal change in scores over time. After future waves of the HRS are collected and coded, more research should be conducted to continue to explore these issues.

Racial/Ethnic Differences in Rates of Decline

The last goal of the study was to investigate changes in cognitive function among white, black, and Hispanic adults. The results showed that, although being black or Hispanic was associated with lower mental status scores and being black was associated with lower memory scores, there were no differences by race/ethnicity in rates of change over a 7 year period.

Memory

Over the course of the study, memory scores declined slightly, though significantly, and there were disparities between black and white participants. However, there were no differences in rates of change by race/ethnicity. This is not consistent with recent research from the AHEAD data that black adults had slower rates of memory decline than white adults (Alley et al., 2007). This may be due to the different age groups studied (late middle age vs. older). It is somewhat consistent with the findings from the Women's Health and Aging Study that there were no differences in rates of decline in MMSE score by race/ethnicity (Atkinson et al., 2005). However, inconsistencies between the HRS and the Women's Health and Aging Study include the study sample (all female versus coed), and the outcome measures used.

Mental Status

Results showed that during the follow-up period, there were no declines in mental status scores but an average gain over time. As mentioned previously, learning effects may have contributed to this finding (Ofstedal et al., 2005). In addition, rates of change did not vary by racial/ethnic group. The finding that there were no differences among white and Hispanic participants' rates of change was inconsistent with Alley and colleagues who found that Hispanic participants declined at a faster rate than white on the mental status measures in the AHEAD (2007). Because the age of the participants in the current analyses (63+) were almost 10 years lower than those in the AHEAD (70+), it is possible that the AHEAD data showed greater variance in change than the HRS, and were able to detect differences by race/ethnicity.

Interpretation of Findings

Physical Activity and Education

The lack of protective effects of either physical activity or education on rates of decline in memory or mental status scores may be due to several factors. First, the unexpected improvement in mental status score prevented study of decline. Secondly, the very small decline that occurred in the memory scores may have prohibited the observation of protective effects of education and physical activity. Finally, it is possible that education and physical activity are associated with differential scores over time, but that they do not impact the rates of decline.

Racial/Ethnic Disparities in Decline

The results may indicate that beginning in late middle age, disparities over time in cognitive scores are present, but that change over time does not vary by race/ethnicity. However, differences may have been found had the changes in memory and mental status scores over time been larger. Future HRS research should continue to observe this trend and document changes over the next several waves.

SENSITIVITY ANALYSES

In order to clarify the results of the study, several sensitivity analyses were conducted. Several technical and measurement adjustments were explored in order to aid the interpretation of the results.

Technical Adjustments

In order to determine if choices made in the analysis plan had an affect on the results, analyses were performed without weights, and proxy respondents and missing data were investigated further. All analyses that were completed with weights, as previously described, were also completed without weights. No differences were found in results from any aim. In addition, proxy respondents and those with missing data were analyzed to clarify the results.

As mentioned previously, proxy respondents were not included in the analyses because of several reasons. They did not answer cognitive function, physical activity, or depressive symptoms questions, among others. 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. In sensitivity analyses, 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 tests were used to compare proxy respondents to non-prosy 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 addition to those who respondent by proxy, there were some missing participants in one of the main outcome measures.

In order to verify that missing data on the outcome variables of interest did not affect the results, several analyses were conducted. For memory score, at baseline there were no missing data. At baseline, there were 265 (out of 7944) participants without mental status scores (3.34%). Those with missing data were no different from those without by age or income status. They were less likely, however, to have graduated from high school, to be female (24%), and to be single ($p<0.0001$). In addition, those with missing data were more likely to be Hispanic than other participants (OR=1.11 $p<0.0001$). It is unlikely that the small number of missing data had significant effects on the analyses. However, if Hispanic persons were less likely to respond to mental status items, this may indicate that something about the measure.

Measurement Adjustments

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 in several different ways. In cross-sectional analyses, education was examined as a categorical variable. However, in the longitudinal analyses, education was examined as a continuous, categorical, and binomial variable. More details can be found in the results Chapter 7 for Specific Aim III.

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 race/ethnicity in the Health and Retirement Study when physical activity measures are used as a scale (He & Baker, 2005). One purpose of the study was to uncover the types of activities that were positively associated with cognitive function, but the use of a total physical activity score was also explored.

The total activity score is derived from recoding the physical activity responses in 1992 as follows. When added together, these recodes produced a total activity score with a range of 0-42. This score was explored for use in the current research and was not chosen for several reasons. First, when the recoded measures were evaluated using factor analysis, the correlation matrix revealed one factor with a low eigenvalue of 0.39. In addition, Cronbach's alpha reliability testing resulted in a 0.28. This demonstrates that the factor provided no greater explanation of physical activity in HRS respondents and added nothing additional to our knowledge about the data set. Secondly, as demonstrated in the result section, the different physical activity measures correlated differently than expected with the outcome measures of interest. Specifically, work physical activity was negatively correlated with measures of cognitive function, whereas the other measures were positively correlated 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 and identify the reasons behind the contradictory correlations. Furthermore, since the number of measures of physical activity decreases in Wave III, the analyses would not be comparable if a score was used to evaluate Aim I & II, but individual physical activity measures were used for Aim III.

Finally, the mental status scores provided by the HRS include one with the "scissors" variable and one without. As previously stated, the mental status item regarding naming a picture of scissors contributed to the low reliability of the score because there was so little variability in responses. Therefore, all analyses were conducted without the scissors item and a mental status score of 0-9. There were no differences in the results of the analyses with the scissors item removed.

Additional Analyses

Because there were no differences in cross-sectional analyses in scores on tests of cognitive function between Hispanic and White adults who were working for pay, work status was examined further. In an attempt to determine if working was protective of decline, longitudinal models were conducted with work by time interactions. Work status was not found to be protective of cognitive decline.

STRENGTHS AND LIMITATIONS

Study Strengths

The HRS data provided an opportunity to study cognitive change over late middle age in a multi-ethnic, nationally representative 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. In addition, the sample still exists today and so the study can be extended to future waves as data are collected and cataloged. There are also several strengths of the covariates available in the HRS.

The inclusion of work-related physical activity coupled with leisure time activity was particularly important and gave a more comprehensive view of a persons' physical activity profile. As mentioned in Chapter 3, one goal of physical activity and cognitive function research is to determine what types of physical activity have the greatest effect on cognitive function. The results of this study are important in that they show that vigorous, light, and, in some cases, housework activity are associated with higher cognitive function scores in late middle age, but that work activity is associated with lower scores. These results strengthen the evidence that only certain types of activities are associated with improved cognitive function. This provides direction for researchers who seek to determine exactly what types of activities have the most substantial impact on cognitive function.

In addition, multi-ethnic comparisons are possible with these data. They provide evidence that there are not racial/ethnic differences in memory decline or mental status change in late middle age. However, these results contribute to, rather than clarify, the conflicting results found in research today.

Study Limitations

Cognitive Function Measures

The mental status items were problematic. In Chapter 5, the results of principal components analyses and tests of reliability showed that the mental status items do not function well together as a scale. 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 match the TICS or any validated modified versions (Welsh et al., 1993; Beeri et al., 2003). Though the reliability did not vary by racial/ethnic group, the items comprise nothing more than a knowledge test. Therefore, it is not possible to know what domain of cognitive function was being measured with the score. Furthermore, Hispanic persons were less likely than whites to refuse to answer the mental status items. This may be indicative of an underlying ethnic bias that was not controlled for by asking the questions in Spanish. In the future, researchers should consider separating the memory from mental status items, and should be very cautious of using the mental status items as outcome measures.

Furthermore, validity of the measures of memory and mental status, as well as the absence of measurement bias, was not established. It is possible that the additional effect of race/ethnicity on cognitive function scores that was unexplained was due, at least in part, to measurement bias. Some research has shown that, in multi-ethnic samples, measurement equivalence exists in some measures that were included in the current analysis such as year, day of the week, and month (Edelen et al., 2006). In the current study, after examining the breakdown of responses on each item in the cognitive function measures, it appears that Hispanic and black participants' lower scores on the mental status items may have been driven by differential responses on the vice president and cactus measures, though this was not confirmed with statistical analyses. However researchers were cautioned about indiscriminately removing the other items that have not yet been proven to be without bias and reanalyzing data because this may affect the ability of the measurement to detect cognitive function problems (content validity) (Borsboom, 2006). Additional research should be conducted to establish measurement equivalence across groups prior to additional analyses of cognitive function in the Health and Retirement Study.

Physical Activity Measures

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. As seen in Table 1.2, respondents were given several choices when answering questions about their light, vigorous, housework, and work-related activities. 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. As shown in Table 5.16, when given several options, 13% of the sample said they engaged in vigorous activity 3 times per week or more. However, 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 unreliable conclusions about the role of physical activity in cognitive function scores over time.

Other Study Limitations

As previously stated, it is unfortunate that the HRS does not include additional information about the quality of the participants' education, literacy, or feelings about everyday discrimination. The inclusion of these measures may have made the findings about education and its mediating role more robust. Furthermore, the mental status items were only asked of those aged 65 and older at 1998 and beyond. Had the measures been asked for all participants at all waves, cognitive function analyses would have been more useful, particularly for Aim III. Instead, the sample used for Aim III for the mental status analyses was older (63+) and could not be considered late middle aged. Therefore, the findings of those analyses were not particularly relevant to the goals of the dissertation.

DIRECTIONS FOR FUTURE RESEARCH

Further research should be conducted using similar analyses as additional waves of HRS data are collected and coded. There may be very useful information about memory decline from late middle to older ages. Because memory is one of the main signs of mild cognitive impairment, dementia, and Alzheimer's disease, it is a very important domain of cognitive function to study.

In addition, the difference of association between leisure-time and work physical activity and cognitive scores warrants closer examination. The current results contribute to the bulk of the literature that vigorous physical activity is associated with higher cognitive function scores, and adds to the literature that physical activity at work may be detrimental to cognitive function. Future research should correlate the type of work physical activity, whether cardiovascular in nature or otherwise, with cognitive function scores to determine if there are specific types of activities that are actually harmful to cognitive function. On the other hand, the work physical activity may be a proxy measure for social class. Those who engage in physical activity at work may be more likely to be in lower paying jobs that involve manual labor. It may not be the work activity that is detrimental, but the socioeconomic status of the participant. These ideas should also be explored.

CONCLUSIONS

The purpose of the study was to explore, in late middle aged adults, the components of the conceptual relationships shown in Figure 1.1. Specifically, the relationships between race/ethnicity and cognitive function were examined cross-sectionally and over time. The mediating effects of physical activity and education were determined, and the potential for protective effects of physical activity and education were established. In this case, racial/ethnic disparities that existed at baseline continued, but did not worsen, over time. Leisure-time physical activity and education partially mediated the relationships between being black or Hispanic and cognitive function scores, but did not fully explain the associations. Furthermore, neither impacted rates of change in cognitive function scores over time.

Although much work has been done to study racial/ethnic differences in cognitive function and cognitive decline, gaps in research remained. The results from this study showed that there are racial/ethnic inequalities in cognitive function as early as late middle age, and that increased education and physical activity patterns may alleviate racial/ethnic disparities in scores on tests of cognitive function. Lastly, the observation that those from one racial/ethnic group do not differ from other groups in the course of decline in memory provides evidence that, though disparities may exist, they do not worsen over time.

Appendix

MEASURES OF COGNITIVE FUNCTION USED TO STUDY THE RELATIONSHIPS AMONG RACE/ETHNICITY, EDUCATION, PHYSICAL ACTIVITY, AND COGNITIVE FUNCTION IN THE HRS

	Wave I	Wave II	Wave III	Wave IV	Wave V	Wave VI
Immediate recall (20-item)	X	X				
Delayed recall (20-item)	X	X				
Immediate recall (10-item)			X	X	X	X
Delayed recall (10-item)			X	X	X	X
Mental status items			X	X	X	X

Immediate Recall (Wave 1)

Next, I'll read a set of 20 words and ask you to recall as many as you can. We have purposely made the list long so that it will be difficult for anyone to recall all the words -- most people recall just a few.

Please listen carefully as I read the set of words. When I finish, I will ask you to recall aloud as many of the words as you can, in any order. Do you have any questions?

a. lake	h. door	q. coffee
b. car	j. mountain	r. steam
c. army	k. pipe	s. cat
d. forest	m. plant	t. winter
e. ticket	n. bird	u. ship
f. city	o. corn	v. dust
g. cabin	p. iron	

Now please tell me the words you can recall.

Delayed Recall (Wave I)

A little while ago, I read you a list of words and you repeated the ones you could remember. Please tell me any of the words that you remember now.

Mental Status Items: (Wave III-VI)

1) Please tell me today's date. PROBE MONTH, DAY, YEAR, DAY OF WEEK. (0-4 pts.)

2) For this next question, please try to count backward as quickly as you can from the number I will give you. I will tell you when to stop. Start at: 20. Let’s try again. The number to count backwards from again is: 20. (0-2 pts.)
3) Now I'm going to ask you for the names of some people and things. What do people usually use to cut paper? (0-1 pt.)
4) What do you call the kind of prickly plant that grows in the desert? (0-1 pt.)
5) Who is the President of the United States right now? (0-1 pt.)
6) Who is the Vice President? (0-1 pt.)

Immediate Recall (Wave III-VI)

I'll read a set of 10 words and ask you to recall as many as you can. We have purposely made the list long so that it will be difficult for anyone to recall all the words -- most people recall just a few. Please listen carefully as I read the set of words because I cannot repeat them. When I finish, I will ask you to recall aloud as many of the words as you can, in any order. Is this clear?

PROBE AS NEEDED FOR UNDERSTANDING OF TASK. READ THE ITEMS AT A SLOW, STEADY RATE AS THEY COME UP ON THE SCREEN, APPROXIMATELY ONE WORD EVERY TWO SECONDS
RESPONDENT IS ASSIGNED RANDOMLY SELECTED SUBSET 1-10 11-20 21-30 31-40

SET 1	SET 2	SET 3	SET 4
1. HOTEL	11. SKY	21. WOMAN	31. WATER
2. RIVER	12. OCEAN	22. ROCK	32. CHURCH
3. TREE	13. FLAG	23. BLOOD	33. DOCTOR
4. SKIN	14. DOLLAR	24. CORNER	34. PALACE
5. GOLD	15. WIFE	25. SHOES	35. FIRE
6. MARKET	16. MACHINE	26. LETTER	36. GARDEN
7. PAPER	17. HOME	27. GIRL	37. SEA
8. CHILD	18. EARTH	28. HOUSE	38. VILLAGE
9. KING	19. COLLEGE	29. VALLEY	39. BABY
10. BOOK	20. BUTTER	30. ENGINE	40. TABLE

Delayed Recall (Wave III)

A little while ago, I read you a list of words and you repeated the ones you could remember. Please tell me any of the words that you remember now.
PERMIT AS MUCH TIME AS RESPONDENT WISHES -- UP TO 2 MINUTES.

References

1) Abbott, R., White, L., Ross, W., Masaki, K., Curb, D., & Petrovitch, H. (2004). Walking and Dementia in Physically Capable Elderly Men. *Journal of the American Medical Association, 292,* 1447-1453.

2) Agency for Healthcare Research and Quality (2006). *2006 National Healthcare Disparities Report* (Rep. No. 07-0012). Rockville, MD: U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality.

3) Albeck, D., Sano, K., Prewitt, G., & Dalton, L. (2006). Mild Forced Treadmill Exercise Enhances Spatial Learning in the Aged Rat. *Behavioural Brain Research, 168,* 345-348.

4) Albert, M., Jones, K., Savage, C., Berkman, L., Seeman, T., Blazer, D., Rowe, J. (1995). Predictors of Cognitive Change in Older Persons: MacArthur Studies of Successful Aging. *Psychology and Aging, 10,* 578-589.

5) Albert, MS. (1995). How Does Education Affect Cognitive Function? *Annals of Epidemiology, 5,* 76-78.

6) Albert, M. & Teresi, J. (1999). Reading Ability, Education, and Cognitive Status Assessment among Older Adults in Harlem, New York City. *American Journal of Public Health, 89,* 95-97.

7) Alley, D., Suthers, K., & Crimmins, E. (2007). Education and Cognitive Decline in Older Americans. Results from the AHEAD Sample. *Research on Aging, 29,* 73-94.

8) American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision*. Washington, DC: American Psychiatric Association.

9) Anderson, J. (1988). *The Education of Blacks in the South, 1860-1935*. Chapel Hill, NC: University of North Carolina Press.

10) Atkinson, H., Cesari, M., Kritchevsky, S., Penninx, B., Fried, L., Guralnik, J., Williamson, J. (2005). Predictors of Combined Cognitive and Physical Decline. *Journal of the American Geriatrics Society, 53,* 1197-1202.

11) Barnes, D., Yaffe, K., Satariano, W., & Tager, I. (2003). A Longitudinal Study of Cardiorespiratory Fitness and Cognitive Function in Healthy Older Adults. *Journal of the American Geriatrics Society, 51,* 459-465.

12) Barnes, L., Mendes de Leon, C., Wilson, R., Bienias, J., & Evans, D. (2004). Social Resources and Cognitive Decline in a Population of Older African Americans and Whites. *Neurology, 63,* 2322-2326.

13) Baron, R. & Kenny, D. (1986). The Moderator-Mediator Variable Distinction in Social Psychological Research: Conceptual, Strategic, and Statistical Considerations. *Journal of Personality and Social Psychology, 51,* 1173-1182.

14) Bassuk, S., Glass, T., & Berkman, L. (1999). Social Disengagement and Incident Cognitive Decline in Community-Dwelling Elderly Persons. *Annals of Internal Medicine, 131,* 167-173.

15) Beeri, M., Werner, P., Davidson, M., Schmidler, J., Silverman, J. (2003). Validation of the Modified Telephone Interview for Cognitive Status (TICS-m) in Hebrew. *International Journal of Geriatric Psychiatry, 18*, 381-386.

16) Bird, T. (2001). Frontotemporal Dementia: Genotypes, Phenotypes, and More Problems to be Solved. *Neurobiology of Aging, 22,* 113-114.

17) Blaum, C., Ofstedal, M., & Liang, J. (2002). Low Cognitive Performance, Comorbid Disease, and Task-Specific Disability: Findings from a Nationally Representative Survey. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 57A,* M523-M531.

18) Blessed, G., Tomlinson, B., & Roth, M. (1968). The Association between Quantitative Measures of Dementia and of Senile Change in the Cerebral Grey Matter of Elderly Subjects. *British Journal of Psychiatry, 114,* 797-811.

19) Borsboom, D. (2006). When Does Measurement Invariance Matter? *Medical Care, 44,* S176-S181.

20) Bowden, S., Cook, M., Bardenhagen, F., Shores, E., Carstairs, J. (2004). Measurement invariance of core cognitive abilities in heterogeneous neurological and community samples. *Intelligence, 32,* 363-389.

21) Brandt, J., Spencer, M., & Folstein, M. (1988). The Telephone Interview for Cognitive Status. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 1,* 111-117.

22) Brandt, J., Welsh, K., Breitner, J., Folstein, M., Helms, M., & Christian, J. (1993). Hereditary Influence on Cognitive Functioning in Older Men. A Study of 4000 Twin Pairs. *Archives of Neurology, 50,* 599-603.

23) Brownson, R., Eyler, A., King, A., Brown, D., Shyu, Y., & Sallis, J. (2000). Patterns and Correlates of Physical Activity among US Women 40 Years and Older. *American Journal of Public Health, 90,* 264-270.

24) Carlson, M. (1998). Lack of Relation between Race and Cognitive Test Performance in Alzheimer's Disease. *Neurology, 50,* 1499-1501.

25) Carlson, M., Fried, L., Xue, Q.-L., Bandeen-Roche, K., Zeger, S., & Brandt, J. (1999). Association between Executive Attention and Physical Functional Performance in Community-Dwelling Older Women. *Journals of Gerontology Series A: Psychological Sciences and Social Sciences, 54B,* S262-S270.

26) Carmines, E. & Zeller, R. (1979). *Reliability and Validity Assessment. Sage University Paper Series on Quantitative Applications in the Social Sciences*. Newbury Park, CA: Sage Publications.

27) Centers for Disease Control and Prevention (2005). Trends in Leisure-Time Physical Inactivity by Age, Sex, and Race/Ethnicity — United States, 1994–2004. *Morbidity and Mortality Weekly Report, 54,* 991-994.

28) Centers for Disease Control and Prevention (2007a). Prevalence of Stroke --- United States, 2005. *Morbidity and Mortality Weekly Report, 56,* 469-474.

29) Centers for Disease Control and Prevention (2007b). *Trends in Health & Aging: Prevalence of Selected Chronic Conditions by Age, Sex, Race/Ethnicity, United States 1997-2005.* U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics. Retrieved August 12, 2007 from http://209.217.72.34/aging/TableViewer/tableView.aspx?ReportId=380.

30) Christensen, H., Korten, A., Jorm, A., Henderson, A., Scott, R., & Mackinnon, A. (1996). Activity Levels and Cognitive Functioning in an Elderly Community Sample. *Age and Ageing, 25,* 72-80.

31) Conley, D. (1999). *Being Black, Living in the Red: Race, Wealth, and Social Policy in America*. Berkeley, CA: University of California Press.

32) Crane, P., Gibbons, L., Jolley, L., & van Belle, G. (2006). Differential Item Functioning Analysis with Ordinal Logistic Regression Techniques: DIFdetect and DIFwithpar. *Medical Care, 44,* S115-S123.

33) Crespo, C., Keteyian, S., Heath, G., & Sempos, C. (1996). Leisure-Time Physical Activity among US Adults: Results from the Third National Health and Nutrition Examination Survey. *Archives of Internal Medicine, 156,* 93-98.

34) Crespo, C., Ainsworth, B., Keteyian, S., Heath, G., & Smit, E. (1999). Prevalence of Physical Inactivity and its Relation to Social Class in U.S. Adults: Results from the Third National Health and Nutrition Examination Survey, 1988-1994. *Medicine & Science in Sports & Exercise, 31,* 1821-1827.

35) Crespo, C., Smit, E., Anderson, R., Carter-Pokras, O., & Ainsworth, B. (2000). Race/Ethnicity, Social Class and their Relation to Physical Inactivity During Leisure Time: Results from the Third National Health and Nutrition Examination Survey, 1988-1994. *American Journal of Preventive Medicine, 18,* 46-53.

36) Cronbach, L. (1951). Coefficient Alpha and the Internal Structure of Tests. *Psychometrika, 16,* 297-334.

37) Diehr, P., Patrick, D., Spertus, J., Kiefe, C., McDonell, M., & Fihn, S. (2001). Transforming Self-Rated Health and the SF-36 Scales to Include Death and Improve Interpretability. *Medical Care, 39,* 670-680.

38) Dorans, N. & Kulik, E. (2006). Differential Item Functioning on the Mini-Mental State Examination: An Application of the Mantel-Haenszel and Standardization Procedures. *Medical Care, 44,* S107-S114.

39) Dunlop, D., Song, J., Lyons, J., Manheim, L., & Chang, R. (2003). Racial/Ethnic Differences in Rates of Depression among Pre-retirement Adults. *American Journal of Public Health, 93,* 1945-1952.

40) Edelen, M., Thissen, D., Teresi, J., Kleinman, M., & Ocepek-Welikson, K. (2006). Identification of Differential Item Functioning Using Item Response Theory and the Likelihood-Based Model Comparison Approach: Application to the Mini-Mental State Examination. *Medical Care, 44,* S134-S142.

41) Emery, C., Honn, V., Frid, D., Lebowitz, K., & Diaz, P. (2001). Acute Effects of Exercise on Cognition in Patients with Chronic Obstructive Pulmonary Disease. *American Journal of Respiratory and Critical Care Medicine, 164,* 1624-1627.

42) Evans, D., Beckett, L., Albert, M., Hebert, L., Scherr, P., Funkenstein, H., Taylor, J. (1993). Level of Education and Change in Cognitive Function in a Community Population of Older Persons. *Annals of Epidemiology, 3,* 71-78.

43) Eyler, A. (2003). Correlates of Physical Activity: Who's Active and Who's Not? *Arthritis & Rheumatism, 49,* 136-140.

44) Farmer, M., Kittner, S., Rae, D., Bartko, J., & Regier, D. (1995). Education and Change in Cognitive Function. The Epidemiologic Catchment Area Study. *Annals of Epidemiology, 5,* 76-78.

45) Fillenbaum, G., Heyman, A., Prosnitz, B., & Burchett, B. (1990). Sensitivity and Specificity of Standardized Screens of Cognitive Impairment and Dementia among Elderly Black and White Community Residents. *Journal of Clinical Epidemiology, 43,* 651-660.

46) Fillenbaum, G., Landerman, L., Blazer, D., Saunders, A., Harris, T., Launer, L. (2001). The Relationship of APOE Genotype to Cognitive Functioning in Older African-American and Caucasian Community Residents. *Journal of the American Geriatrics Society, 49,* 1148-1155.

47) Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-Mental State: A Practical Method for Grading the Cognitive State of Patients for the Clinician. *Journal of Psychiatric Research, 12,* 189-198.

48) Forsell, Y., Jorm, A., & Winbald, B. (1994). Association of Age, Sex, Cognitive Dysfunction, and Disability with Major Depressive Symptoms in an Elderly Sample. *American Journal of Psychiatry, 151,* 1600-1604.

49) Freidenberg, R. (2003). Dementia: One of the Greatest Fears of Aging. *Radiology, 229,* 632-635.

50) Fuster, J. (2003). Physiology of Executive Functions. In D. Stuss & R. Knight (Eds.), *Principles of Frontal Lobe Function* (First ed., pp. 96-108). New York, NY: Oxford University Press.

51) Gasquoine, P. (2001). Research in Clinical Neuropsychology with Hispanic American Participants: A Review. *The Clinical Neuropsychologist, 15,* 2-12.

52) Goldsmith, P. (2003). All Segregation is Not Equal: The Impact of Latino and Black School Composition. *Sociological Perspectives, 46,* 83-105.

53) Greenough, W., Larson, J., & Withers, G. (1985). Effects of Unilateral and Bilateral Training in a Reaching Task on Dendritic Branching of Neurons in the Rat Motor-Sensory Forelimb Cortex. *Behavioral and Neural Biology, 44,* 301-314.

54) Greiner, P., Snowden, D., & Schmitt, F. (1996). The Loss of Independence in Activities of Daily Living: The Role of Low Normal Cognitive Function in Elderly Nuns. *American Journal of Public Health, 86,* 62-66.

55) Gurland, B., Wilder, D., Lantigua, R., Stern, Y., Chen, J., Killeffer, E., Mayeux, R. (1999). Rates of Dementia in Three Ethnoracial Groups. *International Journal of Geriatric Psychiatry, 14,* 481-493.

56) He, X. & Baker, D. (2005). Differences in Leisure-Time, Household, and Work-Related Physical Activity by Race, Ethnicity, and Education. *Journal of General Internal Medicine, 20,* 259-266.

57) Health and Retirement Study (2007). *Tracker 2004; Version 2.0*. Retrieved August 12, 2007 from http://ssl.isr.umich.edu/hrs/filedownload.php?d=487.

58) Hebert, L., Scherr, P., Bienias, J., Bennett, D., & Evans, D. (2003). Alzheimer's Disease in the US Population: Prevalence Estimates Using the 2000 Census. *Archives of Neurology, 60,* 1119-1122.

59) Heeringa, S. & Connor, J. (1995). *Technical Description of the Health and Retirement Study Sample Design* (Rep. No. DR-002). Ann Arbor, MI: Institute for Social Research. University of Michigan.

60) Hess, T. (2006). Attitudes toward Aging and Their Effects on Behavior. In J. Birren & K. Schaie (Eds.), *Handbook of the Psychology of Aging* (Sixth ed., pp. 379-406). Burlington, MA: Elsevier Academic Press.

61) Hill, T., Burdette, A., Angel, J., & Angel, R. (2006). Religious Attendance and Cognitive Functioning Among Older Mexican Americans. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 61,* P3-P9.

62) Jastak, S. & Wilkinson, GS. (1984). *The Wide Range Achievement Test-Revised.* Wilmington, DE: Jastak Associates.

63) Johnson, D., Morris, J., & Galvin, J. (2005). Verbal and Visuospatial Deficits in Dementia with Lewy Bodies. *Neurology, 65,* 1232-1238.

64) Jolliffe, I. (2002). *Principal Component Analysis*. (Second ed.) New York, NY: Springer-Verlag.

65) Jones, R. (2003). Racial Bias in the Assessment of Cognitive Functioning of Older Adults. *Aging & Mental Health, 7,* 83-102.

66) Jones, R. (2006). Identification of Measurement Differences between English and Spanish Language Versions of the Mini-Mental State Examination: Detecting Differential Item Functioning Using MIMIC Modeling. *Medical Care, 44,* S124-S133.

67) Juster, F. & Suzman, R. (1995). An Overview of the Health and Retirement Study. *The Journal of Human Resources, 30,* S7-S56.

68) Kao, G. & Tienda, M. (1990). Educational Aspirations of Minority Youth. *American Journal of Education, 106,* 349-384.

69) Kaufman, J., Cooper, R., & McGee, D. (1997). Socioeconomic Status and Health in Blacks and Whites: The Problem of Residual Confounding and the Resiliency of Race. *Epidemiology, 8,* 621-628.

70) Knopman, D., Boeve, B., & Petersen, R. (2003). Essentials of the Proper Diagnoses of Mild Cognitive Impairment, Dementia, and Major Subtypes of Dementia. *Mayo Clinic Proceedings, 78,* 1290-1308.

71) Kramer, A., Hahn, S., Cohen, N., Banich, M., McAuley, E., Harrison, C., Chason, J., Vakil, E., Bardell, L., Bileau, R., Colcombe, A. (1999). Ageing, Fitness and Neurocognitive Function. *Nature, 400,* 418-419.

72) Kuller, L., Shemanski, L., Manolio, T., Haan, M., Fried, L., Bryan, N., Burke, G., Tracy, R., Bhadelia, R. (1998). Relationship between ApoE, MRI Findings, and Cognitive Function in the Cardiovascular Health Study. *Stroke,* 388-398.

73) Larson, E., Wang, L., Bowen, J., McCormick, W., Teri, L., Crane, P., Kukull, W. (2006). Exercise is Associated with Reduced Risk for Incident Dementia among Persons 65 Years of Age and Older. *Annals of Internal Medicine, 144,* 73-81.

74) Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001). Physical Activity and Risk of Cognitive Impairment and Dementia in Elderly Persons. *Archives of Neurology, 58,* 498-504.

75) Leveille, S., Guralnik, J., Ferucci, L., Corti, M., Kasper, J., & Fried, L. (1998). Black/White Differences in the Relationship between MMSE Scores and Disability: The Women's Health and Aging Study. *Journals of Gerontology Series B: Psychological and Social Sciences, 53,* P201-P208.

76) Link, B. & Phelan, J. (1995). Social Conditions as Fundamental Causes of Disease. *Journal of Health and Social Behavior,* 80-94.

77) Lopez, O., Jagust, W., Dulberg, C., Becker, J., DeKosky, S., Fitzpatrick, A., Breitner, J., Lykestos, C., Jones, B., Kawas, C., Carlson, M., Kuller, L. (2003). Risk Factors for Mild Cognitive Impairment in the Cardiovascular Health Study Cognition Study. *Archives of Neurology, 60,* 1394-1399.

78) Lykestos, C., Chen, L.-S., & Anthony, J. (1999). Cognitive Decline in Adulthood: An 11.5 Year Follow-Up of the Baltimore Epidemiologic Catchment Area Study. *American Journal of Psychiatry, 156,* 58-65.

79) Lytle, M., Vanderbilt, J., Pandev, R., Dodge, H., & Ganguli, M. (2004). Exercise Level and Cognitive Decline: The MoVIES Project. *Alzheimer's Disease and Associated Disorders, 18,* 57-64.

80) Manly, J., Jacobs, D., Touradji, P., Small, S., & Stern, Y. (2002). Reading Level Attenuates Differences in Neuropsychological Test Performance Between African American and White Elders. *Journal of the International Neuropsychological Society, 8,* 341-348.

81) Manly, J., Schupf, N., Tang, M.-X., & Stern, Y. (2005). Cognitive Decline and Literacy among Ethnically Diverse Elders. *Journal of Geriatric Psychiatry and Neurology, 18,* 213-217.

82) Manly, J. (2006). Deconstructing Race and Ethnicity: Implications for Measurement of Health Outcomes. *Medical Care, 44,* S10-S16.

83) Marquez, D. & McAuley, E. (2006). Social Cognitive Correlates of Leisure Time Physical Activity among Latinos. *Journal of Behavioral Medicine, 29,* 281-289.

84) McKay, P., Doverspike, D., Bowen-Hilton, D., & McKay, Q. (2004). The Effects of Demographic Variables and Stereotype Threat on Black/White Differences in Cognitive Ability Test Performance. *Journal of Business and Psychology, 18,* 1-14.

85) Mirowsky, J. & Ross, C. (2003). *Education, Social Status, and Health*. New York, NY: Aldine de Gruyter.

86) Molloy, D., Beerschoten, D., Borrie, M., Crilly, R., & Cape, R. (1988). Acute Effects of Exercise on Neuropsychological Function in Elderly Subjects. *Journal of the American Geriatric Society, 36,* 29-33.

87) Moritz, D., Kasl, S., & Berkman, L. (1995). Cognitive Functioning and the Incidence of Limitations in Activities of Daily Living in an Elderly Community Sample. *American Journal of Epidemiology, 141,* 41-49.

88) Morris, R. (1984). Developments of a Water-Maze Procedure for Studying Spatial Learning in the Rat. *Journal of Neuroscience Methods, 11,* 47-60.

89) Mouton, C. (1997). Special Health Considerations in African-American Elders. *American Family Physician, 55,* 1243-1253.

90) National Center for Health Statistics (2006). *Health, United States, 2006. With Chartbook on Trends in the Health of Americans* (Rep. No. 76-641496). Hyatsville, MD: U.S. Government Printing Office.

91) Nguyen, H., Black, S., Ray, L., Espino, D., & Markides, K. (2002). Predictors of Decline in MMSE Scores among Older Mexican Americans. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 57A,* M181-M185.

92) Nguyen, H., Black, S., Ray, L., Espino, D., & Markides, K. (2003). Cognitive Impairment and Mortality in Older Mexican Americans. *Journal of the American Geriatrics Society, 51,* 178-183.

93) Ofstedal, M., Fisher, G., & Herzog, A. (2005). *Documentation of Cognitive Functioning Measures in the Health and Retirement Study* (Rep. No. DR-006). Ann Arbor, MI: Survey Research Center, University of Michigan.

94) Orzechowski, S. & Sepielli, P. (2003). *Current Population Reports. Net Worth and Asset Ownership of Households: 1998 and 2000* (Rep. No. P70-88). Washington, D.C.: U.S. Government Printing Office.

95) Osborne, J. (2001). Testing Stereotype Threat: Does Anxiety Explain Race and Sex Differences in Achievement. *Contemporary Educational Psychology, 26,* 291-310.

96) Pavlik, V., de Moraes, S., Szklo, M., Knopman, D., Mosley, T., & Hyman, D. (2003). Relation between Cognitive Function and Mortality in Middle-Aged Adults: The Atherosclerosis Risk in Communities Study. *American Journal of Epidemiology, 157,* 327-334.

97) Perlmutter, M. (1988). Cognitive Potential throughout Life. In J. Birren & V. Bengston (Eds.), *Emergent Theories of Aging* (pp. 247-268). New York, NY: Springer.

98) Pereira, K., Huddleston, D., Brickman, A., Sosunov, A., Hen, R., McKhann, G., Sloan, R., Gage, F., Brown, T., Small, S. (2007). An In Vivo Correlate of Exercise-Induced Neurogenesis in the Adult Dentate Gyrus. *Proceedings of the National Academy of Sciences, 104,* 5638-5643.

99) Petersen, R., Smith, G., Waring, S., Ivnik, R., Tangalos, E., & Kokman, E. (1999). Mild Cognitive Impairment: Clinical Characterization and Outcome. *Archives of Neurology, 56,* 303-308.

100) Petersen, R. & Morris, M. (2003). Clinical Features. In R. Petersen (Ed.), *Mild Cognitive Impairment: Aging to Alzheimer's Disease* (pp. 15-40). New York, N.Y.: Oxford University Press.

101) Pfeiffer, E. (1975). A Short Portable Mental Status Questionnaire for the Assessment of Organic Brain Deficit in Elderly Patients. *Journal of the American Geriatrics Society, 23,* 433-441.

102) Preacher, K. & Hayes, A. (2004). SPSS and SAS Procedures for Estimating Indirect Effects in Simple Mediation Models. *Behavior Research Methods, Instruments, & Computers, 36,* 717-731.

103) Proctor, E., Morrow-Howell, N., Chadiha, L., Braverman, A., Darkwa, O., & Dore, P. (1997). Physical and Cognitive Functioning Among Chronically Ill African-American and White Elderly in Home Care Following Hospital Discharge. *Medical Care, 35,* 782-791.

104) Radloff, L. (1977). The CES-D Scale: A Self-Report Depression Scale for Research in the General Population. *Applied Psychological Measurement, 1,* 385-401.

105) Ramirez, M., Teresi, J., Holmes, D., Gurland, B., & Lantigua, R. (2006). Differential Item Functioning (DIF) and the Mini-Mental State Examination (MMSE): Overview, Sample, and Issues of Translation. *Medical Care, 44,* S95-S106.

106) Reese, C., Cherry, K., Norris, L. (1999). Practical Memory Concerns of Older Adults. *Journal of Clinical Geropsychology, 5*, 231-244.

107) Reyes-Ortiz, C., Kuo, Y.-F., DiNuzzo, A., Ray, L., Raji, M., & Markides, K. (2005). Near Vision Impairment Predicts Cognitive Decline: Data from the Hispanic Established Populations for Epidemiologic Studies of the Elderly. *Journal of the American Geriatrics Society, 53,* 681-686.

108) Rodgers, W., Ofstedal, M., & Herzog, A. (2003). Trends in Scores on Tests of Cognitive Ability in the Elderly U.S. Population, 1993-2000. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58B,* S338-S346.

109) Ropper, A. & Brown, R. (2005). *Adam's and Victor's Principles of Neurology.* New York, NY: McGraw-Hill.

110) Rosenbaum, P. & Rubin, D. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biomtricka, 70,* 41-55.

111) Roth, M., Tym, E., Mountjoy, C., Huppert, F., Hendrie, H., Verma, S., Goddard, R. (1986). CAMDEX. A Standardised Instrument for the Diagnosis of Mental Disorder in the Elderly with Special Reference to the Early Detection of Dementia. *British Journal of Psychiatry, 149,* 698-709.

112) Rovio, S., Kareholt, I., Helkala, E., Viitanen, M., Winbald, B., Tuomilehto, J., Soininen, H., Nissinen, A., Kivipelto, M. (2005). Leisure-Time Physical Activity at Midlife and the Risk of Dementia and Alzheimer's Disease. *The Lancet Neurology, 4,* 705-711.

113) Sachs-Ericsson, N. & Blazer, D. (2005). Racial Differences in Cognitive Decline in a Sample of Community-Dwelling Older Adults: The Mediating Role of Education and Literacy. *American Journal of Geriatric Psychiatry, 13,* 968-975.

114) Satariano, W. (2005). *Epidemiology of Aging: An Ecological Approach*. Sudbury, MA: Jones and Bartlett.

115) SAS Institute (2004). *SAS/STAT 9.1 User's Guide, Volumes 1-7.* Cary, NC: SAS Publishing.

116) Scherr, P., Albert, M., Funkenstein, H., Cook, N., Hennekens, C., Branch, L., White, L., Taylor, J., Evans, D. (1988). Correlates of Cognitive Function in an

Elderly Community Population. *American Journal of Epidemiology, 128,* 1084-1101.

117) Schwartz, B., Glass, T., Bolla, K., Stewart, W., Glass, G., Rasmussen, M., Bressler, J., Shi, W., Bandeen-Roche, K. (2004). Disparities in Cognitive Functioning by Race/Ethnicity in the Baltimore Memory Study. *Environmental Health Perspectives, 112,* 314-320.

118) Seeman, T., Huang, M.-H., Bretsky, P., Crimmins, E., Launer, L., & Guralnik, J. (2005). Education and APOE-e4 in Longitudinal Cognitive Decline: MacArthur Studies of Successful Aging. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 60B,* P74-P83.

119) Simons, L., Simons, J., McCallum, J., & Friedlander, Y. (2006). Lifestyle Factors and Risk of Dementia: Dubbo Study of the Elderly. *The Medical Journal of Australia, 184,* 68-70.

120) Sloan, F. & Wang, J. (2005). Disparities among Older Adults in Measures of Cognitive Function by Race or Ethnicity. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 60B,* P242-P250.

121) Sobel, M. (1982). Asymptotic Intervals for Indirect Effects in Structural Equations Models. In S. Leinhart (Ed.), *Sociological Methodology 1982* (pp. 290-312). San Francisco, CA: Jossey-Bass.

122) Spotila, J. (2000). Standards for Defining Metropolitan and Micropolitan Statistical Areas: Notice. *Federal Register, 65,* 82228-82238.

123) St. Clair, P., Blake, D., Bugliari, D., Chien, S., Hayden, O., Hurd, M., Ilchuk, S., Kung, F.-Y., Miu, A., Panis, C., Pantoja, P., Rastegar, A., Rohwedder, S., Roth, E., Wedell, J., Zissimopolous, J. (2006). *RAND HRS Data Documentation, Version F.* Retrieved August 17, 2007 from http://www.rand.org/labor/aging/dataprod/randhrsf.pdf.

124) Steele, C. & Aronson, J. (1995). Sterotype Threat and the Intellectual Test Performance of African Americans. *Journal of Personality and Social Psychology, 69,* 797-811.

125) Steele, C. (1997). A Threat in the Air. How Stereotypes Shape Intellectual Identity and Performance. *American Psychologist, 52,* 613-629.

126) Stern, Y., Albert, S., Tang, M.-X., & Tsai, W.-Y. (1999). Rate of Memory Decline in AD is Related to Education and Occupation: Cognitive Reserve? *Neurology, 53,* 1942-1947.

127) Sternfeld, B., Ainsworth, B., & Quesenberry, C. (1999). Physical Activity Patterns in a Diverse Population of Women. *Preventive Medicine, 28,* 313-323.

128) Stump, T., Callahan, C., & Hendrie, H. (2001). Cognitive Impairment and Mortality in Older Primary Care Patients. *Journal of the American Geriatrics Society, 49,* 934-940.

129) Sturman, M., Morris, M., Mendes de Leon, C., Bienias, JL., Wilson, R., & Evans, D. (2005). Physical Activity, Cognitive Activity, and Cognitive Decline in a Biracial Community Population. *Archives of Neurology, 62,* 1750-1754.

130) Suthers, K., Kim, J., & Crimmins, E. (2003). Life Expectancy with Cognitive Impairment in the Older Population of the United States. *Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58,* S179-S186.

131) Teng, E. & Chui, H. (1987). The Modified Mini Mental State (3MS) Examination. *Journal of Clinical Psychiatry, 48,* 314-318.

132) Teresi, J., Golden, R., Cross, P., Gurland, B., Kleinman, M., Wilder, D. (1995). Item Bias in Cognitive Screening Measures: Comparisons of Elderly White, Afro-American, Hispanic and High and Low Education Subgroups. *Journal of Clinical Epidemiology, 48,* 473-483.

133) Teresi, J. (2006). Different Approaches to Differential Item Functioning in Health Applications: Advantages, Disadvantages, and Some Neglected Topics. *Medical Care, 44,* S152-S170.

134) Trost, S., Owen, N., Bauman, A., Sallis, J., & Brown, W. (2002). Correlates of Adults' Participation in Physical Activity: Review and Update. *Medicine & Science in Sports & Exercise, 31,* 1996-2001.

135) U.S. Census Bureau (2006). *Mean and Median Family Size by Race and Ethnic Group, 2000.* Washington, DC: American Community Survey Office.

136) U.S. Census Bureau (2007). *Table 1: Annual Estimates of the Population by Five-Year Age Groups and Sex for the United States: April 1, 2000 to July 1, 2006* (Rep. No. NC-EST2006-01). Washington, D.C.: U.S. Government Printing Office.

137) U.S. Congress. House (2007). *Expressing the Sense of the House of Representatives Concerning Health Promotion and Disease Prevention*. 110th Cong. H. Res. 19.

138) U.S. Department of Health and Human Services (2000). *Healthy People 2010. 2nd Ed. With Understanding and Improving Health, and Objectives for Improving Health. 2 Vols.* Washington, D.C.: U.S. Government Printing Office.

139) van Gelder, B., Tijhuis, M., Kalmijn, S., Giampaoli, S., Nissinen, A., & Kromhout, D. (2004). Physical Activity in Relation to Cognitive Decline in Elderly Men. The FINE Study. *Neurology, 63,* 2316-2321.

140) Van Ness, P. & Kasl, S. (2003). Religion and Cognitive Dysfunction in an Elderly Cohort. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58,* S21-S29.

141) van Praag, H., Schubert, T., Zhao, C., & Gage, F. (2005). Exercise Enhances Learning and Hippocampal Neurogenesis in Aged Mice. *The Journal of Neuroscience, 25,* 8680-8685.

142) Welsh, K., Breitner, J., Magruder, H. (1993). Detection of Dementia in the Elderly Using Telephone Screening for Cognitive Status. *Neuropsychiatry, Neuropsychology, and Behavioral Neurology, 6,* 103-110.

143) Weuve, J., Kang, J., Manson, J., Breteler, M., Ware, J., & Grodstein, F. (2004). Physical Activity, Including Walking, and Cognitive Function in Elderly Women. *Journal of the American Medical Association, 292,* 1461.

144) Whitfield, K., Fillenbaum, G., Pieper, C., Albert, M., Berkman, L., Blazer, D., Rowe, J., Seeman, T. (2000). The Effect of Race and Health-Related Factors on Naming and Memory. *Journal of Aging and Health, 12,* 69-89.

145) Williams, D., Yu, Y., Jackson, J., & Anderson, N. (1997). Racial Differences in Physical and Mental Health. *Journal of Health Psychology, 2,* 335-351.

146) Wilson, R., Bennett, D., Beckett, L., Morris, M., Gilley, D., Bienias, J., Scherr, P., Evans, D. (1999). Cognitive Activity in Older Persons from a Geographically Defined Population. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences, 54B,* P155-P160.

147) Wolinsky, F., Miller, T., Geweke, J., Chrischilles, E., An, H., Wallace, R., Pavlik, C., Wright, K., Ohsfelt, R., Rosenthal, G. (2007). An Interpersonal Continuity of Care Measure for Medicare Part B Claims Analyses. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 62,* S160-S168.

148) Wright, C., Lee, H., Paik, M., Stabler, S., Allen, R., & Sacco, R. (2004). Total Homocysteine and Cognition in a Tri-Ethnic Cohort: The Northern Manhattan Study. *Neurology, 63,* 254-260.

149) Yaffe, K., Barnes, D., Nevitt, M., Lui, L., & Covinsky, K. (2001). A Prospective Study of Physical Activity and Cognitive Decline in Elderly Women: Women Who Walk. *Archives of Internal Medicine, 161,* 1703-1708.

150) Yeh, S. & Liu, Y.-Y. (2003). Influence of Social Support on Cognitive Function in the Elderly. *BMC Health Services Research, 3,* 1-9.

151) Yoder, C., Weitzen, S., Pickle, L., Grant, B., Hermann, D., & Schnitzer, S. (2001). Cognitive Functioning in the Last Year of Life as a Function of Age, Gender, and Race. *Experimental Aging Research, 27,* 241-256.

152) Zsembik, B. & Peek, M. (2001). Race Differences in Cognitive Function among Older Adults. *Journal of Gerontology Series B: Psychological Sciences and Social Sciences, 56,* S266-S274.

153) Zunzunegui, M., Alvarado, B., Del Ser, T., & Otero, A. (2003). Social Networks, Social Integration, and Social Engagement Determine Cognitive Decline in Community-Dwelling Spanish Older Adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 58,* S93-S100.

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Peek MK, Masel MC. "Marital Relationships." Encyclopedia of Aging, 4th Edition. Schulz, R. (ed.). NY: Springer 2006.

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