COGNITIVE FUNCTION ACROSS SELF-IDENTIFIED ETHNO-RACIAL GROUPS: THE ROLE OF DISCRIMINATION, ALLOSTATIC LOAD, AND HEALTH BEHAVIORS

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ABSTRACT

Background. Cognitive functioning has been shown to vary by race, education, socioeconomic status, and other demographic factors. Although allostatic load is associated with cognitive functioning this association has not been explored in conjunction with the association between race and cognition and race and allostatic load. Among the literature regarding allostatic load there is a demonstrated gap in research regarding health behaviors and their association with allostatic load beyond controlling for their effect. This research aims to fill these literature gaps and to advance understanding regarding the apparent racial differences in cognitive functioning.

Method. Analyses included data from the Multiethnic Study of Atherosclerosis (MESA) parent study and the Stress sub-study from MESA. The first analysis included latent class analysis using biological indicators and latent class regression using health behavior data from the participants in the Stress sub-study. The second analysis was a path analysis including participants who had full allostatic load and cognitive functioning data from the MESA parent study. The third analysis utilized multivariable linear regression with interaction terms and included participants from the parent study who had full discrimination and allostatic load data.

Results. Four classes were identified in the sample. The metabolic plus blood pressure class was found to be significantly associated with amount of physical activity and alcohol use. Cognitive function differed by race, amount of discrimination, and allostatic load score. Allostatic load score was associated with race and certain health behaviors. Allostatic load at exam 1 was positively associated with chronic discrimination, however change in allostatic load from exam 1 to exam 5 was negatively associated with chronic discrimination. No form of coping moderated the association between allostatic load and chronic discrimination nor did social support. Internal and external coping styles were found to be associated with baseline allostatic load and change in allostatic load independent of amount of chronic discrimination.

Discussion. Differences in cognitive test scores by race beyond amount of discrimination, allostatic load, health behaviors, socioeconomic disadvantage, age, and gender underline the need for further research regarding cognitive functioning among minorities. In light of the rapidly changing ethnic and racial make-up of the aging population these needs take on particular importance. The associations between discrimination and allostatic load highlight the importance of better understanding of how discrimination affects physical health and what factors may mitigate that association. Public health implications are discussed.

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CHAPTER 1: INTRODUCTION

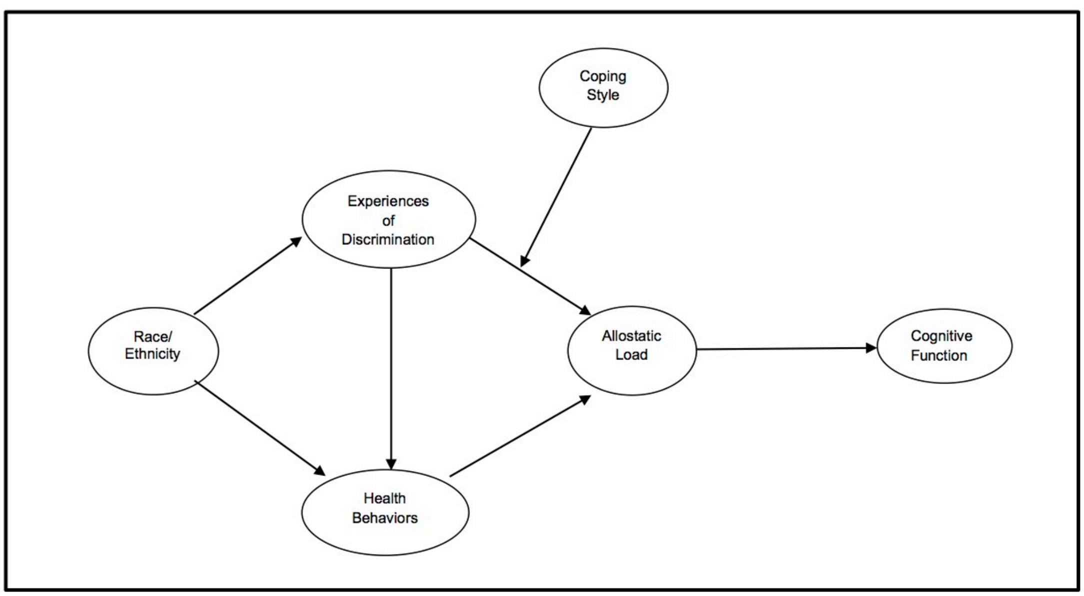
1.1. STATEMENT OF THE PROBLEM

In 2012, 43.1 million Americans were aged 65 and older with 86% White and 9% Black. By 2050 that number is expected to nearly double to 83.7 million with 77% White and 12% Black.[1] The rapidly aging population as well as the changing racial make-up of the aging population underscores the importance of studies regarding cognitive function and racial disparities. Racial disparities are common in health disorders such as diabetes where nearly twice as many Blacks have diabetes as Whites[2] and hypertension where the prevalence is 1.5% higher in Blacks than it is in Whites.[3] These diseases are also disproportionately higher in older adults compared to middle-aged and younger adults. Also well known, but less understood, are racial disparities in cognitive function. Middle-aged and older Blacks have been shown to have poorer cognitive functioning independent of education level and socioeconomic status, although the reasons are unknown.[4] One predictor that has been suggested is perceived discrimination. Indeed, perceived discrimination has been associated with many negative outcomes including increased substance use, increased cardiovascular risk, and worse physical and mental health.[5-8] Although perceived discrimination has been linked to these outcomes, again, the mechanism through which discrimination may work is unknown. A mechanism that has received recent attention is "biological wear and tear" known as Allostatic Load (AL). Understanding the reasons for the disparity in cognitive functioning and the mechanism through which it works could be of great public health significance because an increased understanding may reveal areas for intervention that could benefit an aging and diverse population.

1.2. CONCEPTUAL FRAMEWORK

Figure 1 illustrates the hypothesized relationships between the main study variables. Aim 1 focuses on the relationship between the components of health behaviors and the components of allostatic load. Aim 2 explores possible mechanisms for the cognitive disparity through a path analysis that measures the association of race, discrimination, health behaviors, and cognitive function. Aim 3 concentrates on a possible moderation of the relationship between perceived discrimination and allostatic load. The paths in the figure are illustrated with arrows based on previous literature. However, any findings from this analysis will be considered associations rather than effects since the study data being utilized are not from a randomized controlled trial.

Figure 1.1. Conceptual model of relationship between study variables.



1.3 SPECIFIC AIMS

The main goal of this study is to explore allostatic load as a putative mechanism through which discrimination may work to account for the continued racial disparity in cognitive function beyond education and socioeconomic status and to better understand if the way one copes with discrimination modifies the relationship between discrimination and AL. For aim 1, secondary data from the Multiethnic Study of Atherosclerosis (MESA) Stress Sub-study, a sub-sample of MESA with complete biological measures, cognitive measures, and social measures will be employed. For aims 2 and 3 the the full sample of participants from MESA will be utilized. Although the study is cross-sectional, it is unique in its sample's racial make-up and availability of biological measures. The three specific aims of this study are:

Aim 1: Empirically identify groups of adults with different patterns of biological indicators of allostatic load and investigate the relationship between health behaviors (smoking, drinking, exercise, and diet) and allostatic load. In the first aim we want to fill the literature gap on the relationship between health behaviors and the construct of AL. First, a latent class analysis will be fit to characterize allostatic load in this sample, then latent class regression of individual health behaviors will be conducted to determine if there is a relationship between health behaviors and allostatic load.

Aim 2: Determine the relationship between allostatic load and cognitive function across self-identified ethno-racial groups as a function of experiences of perceived discrimination and poor health behaviors. The second aim is to build and test a path model that quantifies the associations between the main predictors and outcomes. Paths tested will include race ⇒ discrimination, race ⇒health behaviors, race ⇒ allostatic load, race ⇒ cognitive function, discrimination ⇒ health behaviors, discrimination ⇒ allostatic load, discrimination ⇒ cognitive function, and allostatic load ⇒ cognitive function.

Aim 3: To assess possible moderation of coping style and social support on the relationship between perceived discrimination and allostatic load. In the third aim the relationship between discrimination and allostatic load (baseline allostatic load and change from baseline allostatic load to allostatic load at exam 5) will be quantified. We will then assess whether type of coping and amount of social support moderates the relationship. Linear regression analysis with interaction terms defined as perceived discrimination*coping style will be used to test moderation.

1.4. PUBLIC HEALTH SIGNIFICANCE

The predicted growth in the minority aging population makes it especially important to understand disparities in age related cognitive changes. Better understanding of the correlates of cognitive functioning disparities will make it possible to design interventions at earlier stages that could eliminate such disparities, which is a nationwide goal for Healthy People 2020.[9] In the National Prevention Strategy for Elimination of Health Disparities[10] the federal government has vowed to "develop and evaluate community-based intervention to reduce disparities and health outcomes" and "identify and map high-need areas that experience health disparities and align existing resources to meet these needs." This research is also aligned with the goal to "Advance Scientific Knowledge and Innovation" in the Minority Health section of the Department of Health and Human Services. In order to complete these goals, it is imperative to better understand why the disparities exist and through what mechanism they work. This project is intended to be a first step to better understand how discrimination and biological correlates may contribute to the disparity in cognitive function.

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CHAPTER 2: LITERATURE REVIEW

The following review will focus on prior research of the main study outcomes and associations of the main predictors and outcomes, specifically between race and all other outcome variables, discrimination and all other outcome variables, coping and discrimination, and allostatic load and cognitive function.

2.1. COGNITIVE FUNCTION

Language, memory, executive function, attention, perception, judgment, and thought make up the basic functions that we call cognition. These functions, especially memory and executive function, show normative age-related decline but can become pathologically problematic in those who suffer from cognitive impairment and dementia. Poor cognitive function affects both activities of daily living and mortality.[1] The CDC (2011)[2] reports that in a study of 5 states (CA, FL, IA, LA, and MI), the percentage of adults with perceived cognitive impairment (no diagnosis, subjectively reported confusion and memory loss that has gotten worse over the last 12 months) ranged from 4-8% in those aged 18 to 49 years and from 9-15% among those aged 50 and older. Interestingly, cognitive function is not only vital to daily life, it is also a capacity that Americans fear losing the most. One survey found that the twice as many Americans fear losing their mental capacity compared to losing physical ability.[2]

Each aspect of cognitive ability is unique but they all work together to create cognition. Executive functioning involves the ability to integrate the past and present to predict what will happen in the future and it is closely related to thinking, reasoning, and how they play into the way one acts. Attention is the ability to focus and to sustain that focus and it is intertwined with executive functioning, as it is a required component of executive functioning. Memory is the ability to retain experiences and involves multiple brain networks. Physical and social environment as well as health, medications, and emotions can all affect memory. Perception and judgment are both part of executive functioning.

Cognitive abilities can be separated into two types: fluid abilities and crystallized abilities. Fluid abilities include the skills of drawing inferences, being flexible and adaptive, and being able to understand relationships between concepts that don't require knowledge and experience. In contrast, crystallized abilities include the knowledge that is gained through life experiences and is closely tied to culture. Most standardized tests of cognitive skills measure fluid abilities. As individuals age their fluid abilities tend to decline over time while their crystallized abilities improve over time. There is, however, great variability in the rates of decline across individuals.

Most often, intelligence and neuropsychological tests are use to measure cognitive functioning. There are multiple tests in existence, some that measure fluid abilities and some that measure crystallized abilities. It is very important, however, to interpret the tests in light of social and physical environment, physical and mental health, genetic factors, education, culture, and language.

2.2. ALLOSTATIC LOAD

Allostasis is a normal physiological adaptation mechanism, which allows bodily systems to react to threat and stress when necessary. However, prolonged chronic stress causes problematic response or non-response of these systems resulting in a biological toll termed allostatic load (AL).[3] As such, AL is an indicator of multisystem dysregulation that results from this biological toll. Common bodily systems used in constructing an AL score are metabolic, cardiovascular, HPA, parasympathetic, sympathetic, and inflammatory. Different studies have used different strategies to assess AL due to available measures as in NHANES,[4-6] the MacArthur Studies of Successful Aging,[7] CARDIA,[8] and MIDUS.[9, 10] Outcomes related to AL vary but have included both physical disorders (hypertension, cardiac disease, diabetes, stroke, mortality)[11] and mental function (cognitive functioning, depression).[12-16] Although AL is thought to be cumulative and has been shown to increase with age, high AL has been shown to be present in adolescence [17, 18] and middle age [4, 5, 19-21] in addition to older age.[7, 9, 22, 23]

Research regarding predictors of AL has been extensive over the last five or six years. Some of the research has found the following predictors to be associated with AL: low socioeconomic status both in adulthood and childhood,[6, 8, 9, 17, 24] low sense of control and high perceived inequality,[10] acute depressive symptoms,[23] Alzheimer's Disease (AD) caregiving,[18, 22] perceived discrimination, shorter telomeres,[25] race,[4, 20] and chronic stress (work, financial, and caregiving).[21] This proposal focuses /on the association between allostatic load and cognitive function as it relates to race, discrimination, and health behaviors.

2.3. RACE

Research regarding race is important, but the use and measurement of race as a variable in research has been fraught with problems. Since anthropologists have pointed out that race is not a biological concept[26] but is rather a social classification, researchers must consider the factors indexed by race, and how measured and unmeasured factors associated with race influence covariates and outcomes. When considering race as a research variable, it is advisable to realize that "controlling for" race in a model is not an adequate treatment of such a complex variable.[27] Race is undoubtedly intertwined with socioeconomic status, education, group identification, and other social factors that cannot be captured with a "0" or a "1" in a statistical model. Researchers often do not have the option of measuring race in a more comprehensive way, but it is critical to complete analyses with the caveat that the "race" variable is a marker or proxy for many factors that must be incorporated into interpretation.

2.3.1. RACE AND COGNITIVE FUNCTION

Cognitive functioning varies individually due to a host of factors including age, childhood factors such as socioeconomic status in childhood and maltreatment,[28, 29] obesity,[13, 14, 30] and race. Even in persons who do not suffer from cognitive impairment, cognitive function has been found to differ across racial groups.[31-35] In older populations (age 70+) scores on cognitive tests of verbal recall, number series, and global cognition were significantly lower for Blacks and Hispanics compared to Whites, with Blacks having the lowest scores overall.[32, 33] Social factors such as socioeconomic status and lack of education accounted for only some of the variation in cognitive scores between Blacks and Whites.

Shadlen and colleagues (2006)[34] attempted to tease out the effects of education and race on risk of dementia. As expected, black subjects with 10 or fewer years of education had a significantly higher risk of dementia than white subjects with either 10 or fewer years or 10 or more years of education. Most striking, when black subjects with 10 or more years of education were used as the reference group, black subjects with 10 or fewer years of education had nearly three times the risk of dementia but white subjects with 10 or fewer years of education had no excess risk of dementia when compared to black subjects with 10 or more years of education. These findings may be due to the quality of education [36] offered to black subjects considering that the black subjects were significantly younger than the white subjects and that they would have been in school during the Jim Crow era (e.g. segregated schools with less per capita spending on students and lower quality education). Similarly, other studies have shown that even when controlling for age, sex, SES, education, occupational attainment, and physical health (health behaviors, history of stroke, medication for hypertension, and BMI), Black subjects performed consistently and significantly worse on multiple domains of cognitive function (language, non-verbal reasoning, general intelligence, motor speed, eye-hand coordination, verbal learning, verbal memory, executive abilities).[31, 35] It is unknown why race appears to be associated with poorer cognitive function beyond social factors such as education and SES, but better understanding of this difference has the potential to improve cognition and thus quality of life in older minorities.

2.3.2. RACE AND ALLOSTATIC LOAD

Multiple studies have found a higher burden of AL in American born Blacks compared to other races.[4, 5, 19, 20] Studies by both Chyu and Upchurch (2011)[5] and Peek and colleagues (2010)[4] illustrated a higher burden of AL for Blacks than Whites, Mexicans, and Mexican-Americans. The Chyu and Upchurch study supports Geronimus' (2006)[20] concept of "weathering" or the phenomenon of black individuals biologically aging earlier than white individuals. Geronimus posits that blacks that show signs of weathering will appear biologically older than their white counterparts of the same age. Geronimus illustrated this concept in a 2006 study in which she showed that black participants had higher AL scores than white participants in all age groups and that the black-white gap actually continued to increase from ages 18 through 64. For example, the probability of having a high AL score (defined as 3 or higher) was 60% for blacks at age 50 whereas white participants didn't have a probability that high until they reached age 60. Sensitivity analysis was conducted where the definition of a "high" score was changed to 4 or higher however, the results did not change. Overall, within each age group the mean score for Blacks was comparable to the mean score of Whites who were 10 years older. When socioeconomic status was included in the analysis, it was discovered that Whites who were poor were less likely to have a high allostatic load score than Blacks who were not poor. Among those who were not poor, Blacks were five times as likely as Whites to have a high allostatic load score.

Chyu and Upchurch (2011)[5] found similar results to support the weathering hypothesis. Their study demonstrated that among women, Blacks aged 40-49 had AL scores 14% higher than White women ages 50-59 and by the time Blacks reached 50-59 years their AL score was 24% higher than White women of the same age. Interestingly, but not unsurprisingly, in addition to higher total AL score, Blacks appear to have higher cardiovascular and inflammatory subscores than American and foreign-born Mexicans, and significantly higher sub-scores than Whites.[4] Mexican-Americans showed higher AL scores than foreign-born Mexicans as well. Higher mortality in Blacks appears to be partially explained by higher AL score even when socioeconomic status and individual health behaviors are taken into account, suggesting that intervening on AL at earlier ages may have some effect on the disparate mortality rate of Blacks.[19]

2.3.3. RACE AND HEALTH BEHAVIORS

Health behaviors such as smoking, drinking alcohol, diet, and leisure time exercise are associated with both physical and mental health. Race and socioeconomic status have both been shown to affect health behaviors, particularly diet and exercise. Persons who are poorer and black are less likely to meet food guideline recommendations due to lack of good food sources and the inability to afford food that is not highly processed, salty, and sugary.[37, 38] Physical activity during leisure time also appears to be less common among Blacks compared to Whites. Even though Blacks are often more physically active at work, they are less likely to engage in physical activity when they have free time.[39, 40] Many reasons could be considered for this disparity such as fear of going outside in violent neighborhoods, holding down more than one job and not having leisure time, poor outside structure (lack of sidewalks), and being a caretaker to name a few. Comparison of the prevalence of smoking among Whites and Blacks has been less clear. Some studies have found a higher prevalence of smoking among Blacks, other studies have found a higher prevalence among Whites, and still other studies have found similar prevalence between Blacks and Whites.[39] Alcohol use and dependence appears to be more prevalent among the White population. Older blacks are more likely to abstain from alcohol than older Whites.[41] Blacks are less likely to become dependent and develop an alcohol use disorder than Whites,[42] and Whites are more likely than Blacks to initiate alcohol use at a younger age and more quickly develop dependence.[43]

2.4. DISCRIMINATION

2.4.1. DISCRIMINATION AND RACE

Discrimination due to race has long been present in US society and over the last six or seven decades Blacks have shouldered a large burden of such discrimination. Older Blacks grew up in the era of segregation and Jim Crow and as such, dealt with blatant, legal discrimination. Middle-aged and younger blacks have grown up in an era in which discrimination was assumed to be eradicated or at least ameliorated, and policies such as affirmative action were created to make things more "fair" for Blacks. Nevertheless, Blacks still continue to deal with covert and overt discrimination based on race. Kessler (1999)[44] used data from the Midlife in the United States (MIDUS), a nationally representative study, and found that non-Hispanic blacks were nearly 13 times more likely than non-Hispanic whites to report frequent day-to-day discrimination and twice as likely to report having had any major lifetime discrimination event. Similarly, Nearly 90% of non-Hispanic Blacks listed race/ethnicity as a reason for discrimination as opposed to only 21% of non-Hispanic Whites. A more recent study[45] found that 89% of participants reported some form of discrimination and more than half (63.5%) attributed the discrimination to race/ethnicity. In the US it appears that both US-born and Caribbean-born blacks experience racial discrimination. Nearly 45% of a sample of US-born and Caribbean-born Blacks reported experiencing three or more experiences of discrimination (49% for US-born; 41% for Caribbean-born) with the most common domains of discrimination experiences being getting service in a store or restaurant (44%), interacting with the police or in courts (38%) and on the street or in a public setting (38%).[46] There are many more studies that demonstrate greater perceived discrimination in Blacks than in Whites.[47-50] Outcomes of racial discrimination include increased substance use,[49, 51] increased psychological distress,[52] worse physical and mental health in women,[53] increased cardiovascular risk,[50] and poor diet and medication adherence.[54, 55]

2.4.2. DISCRIMINATION AND ALLOSTATIC LOAD

Allostatic load has also been studied as an outcome of perceived discrimination (not exclusively racial discrimination) and although this research is still relatively new and mainly in adolescents, it is relevant to consider here. One study found that Black adolescents who reported high, stable levels of perceived discrimination were more likely to have a higher AL score at age 20 than adolescents who reported low but increasing levels of perceived discrimination.[18] Interestingly, the investigators found that adolescents in the "high and stable" group showed near normal levels of AL at age 20 if they had protective emotional support. This indicates that, at least in adolescents, emotional support can help to buffer the effects of discrimination on AL. Fuller-Rowell and colleagues (2012)[56] found that social class discrimination accounted for 13% of the effect of poverty on AL indicating that discrimination, even when it's not racial, affects AL through poverty. Studies have also found that perceived discrimination is associated with the biological stressor of the systems that make up the components of AL such as cardiovascular factors,[50] inflammation,[57] glucocorticoids,[58] and C-Reactive Protein.[59] Taken together, it appears that perceived discrimination, both racial and other forms, is associated with AL as a whole and with biological mediators that comprise AL.

2.4.3 DISCRIMINATION AND COGNITIVE FUNCTION

Although race, discrimination, and allostatic load have previously been studied as predictors of cognitive function, most models do not include all of these factors. Race and discrimination are often studied together as racial discrimination is one of the more pervasive and common forms of discrimination. As one would expect, even in a so-called "post-racial" society, racial discrimination tends to disproportionately affect Blacks compared to Whites.[44, 45, 47-50] Although Blacks tend to shoulder a larger burden of discrimination, their cognitive functioning appears to be most affected when discrimination is ambiguous as opposed to blatant when their cognitive function appears to increase,[60] whereas the opposite effect is seen in Whites.[61] Due to the limited number of studies on the topic it is unknown if this is a consistent finding. The current study aims to add to that body of research.

2.4.4. DISCRIMINATION AND HEALTH BEHAVIORS

Research has shown that those who report perceived discrimination are more likely to engage in unhealthy behaviors as a way to cope. In one study, African Americans who reported experiencing discrimination in at least 3 of 7 domains had nearly twice the likelihood of reporting tobacco and alcohol use than their counterparts who did not report discrimination,[51] although this is associative and not causal, it does show a strong pattern of alcohol and tobacco use in those who report discrimination. In the Multiethnic Study of Atherosclerosis (MESA), participants who reported racial/ethnic discrimination were more likely to engage in unhealthy behaviors such as smoking and drinking, for all racial groups studied (White, Black, Hispanic). The present research is intended to build on this research by including other factors that may be associated with discrimination and health behaviors in a subset of the MESA sample.

2.4.5. COPING WITH DISCRIMINATION

Coping with stress in general has been found to differ slightly by age group and ethnicity. Meléndez et al (2012)[62] found that older adults tended to use negative self-focus and religiosity to cope with various kinds of stress whereas middle-aged adults were more likely to use a problem solving focus strategy. Younger adults were more likely to use overt emotional expression, avoidance, and social support. The study also found that women were more likely to use all coping styles (negative self-focus, overt emotional expression, avoidance, social support seeking and religion) than men. A review of cross-cultural coping styles[63] showed that African-Americans tend to use religious, spiritual, and ritual-based coping. Latinos/Latinas also use religious and spiritual based coping in addition to family support. Asians are more likely to use avoidance, withdrawal, and forbearance coping methods. Emotion-focused coping was found to be beneficial for Asians but detrimental for African Americans while problem-focus coping was found to be detrimental for Latinos/Latinas.

Discrimination-specific coping studies have shown that there is no universal preferred method for coping with race-based discrimination. Common coping strategies are strong ethnic identity,[64] social support,[18, 65, 66] avoidance,[65, 67] "do something about it",[68] and accepting it as a fact of life. Prior research has shown that suppressing anger from racial discrimination is associated with higher blood pressure.[67] In one study women preferred to deal with individual racism by using avoidance coping rather than problem solving or social support.[66] However, there are no data on the physiological health of these women. Foster (2000)[65] found that the more students use social support to cope with discrimination the less likely they were to feel helpless while the more they used avoidance coping, the more likely they were to feel helpless. One recent study was conducted that included the elements of racial discrimination in blacks, coping, and allostatic load.[18] The study found that adolescents who reported high levels of perceived racism and had emotional support had AL levels similar to those who reported low perceived discrimination. Thus, it appears that how one copes with discrimination may not only be associated with mental health, but physical health as well.

Given the evidence for the associations between AL and cognitive function; race and cognition, AL, and health behaviors; and discrimination and race, AL, and health behaviors, research that models all of these factors could reveal relationships that have not been previously found. The Multiethnic Study of Atherosclerosis offers a unique opportunity to study all of these variables simultaneously. If relationships are found that explain some of the racial variance in cognitive function, unaccounted for by social factors, even small associations could be large in the context of public health given the rapidly aging and racially diverse population of the United States.

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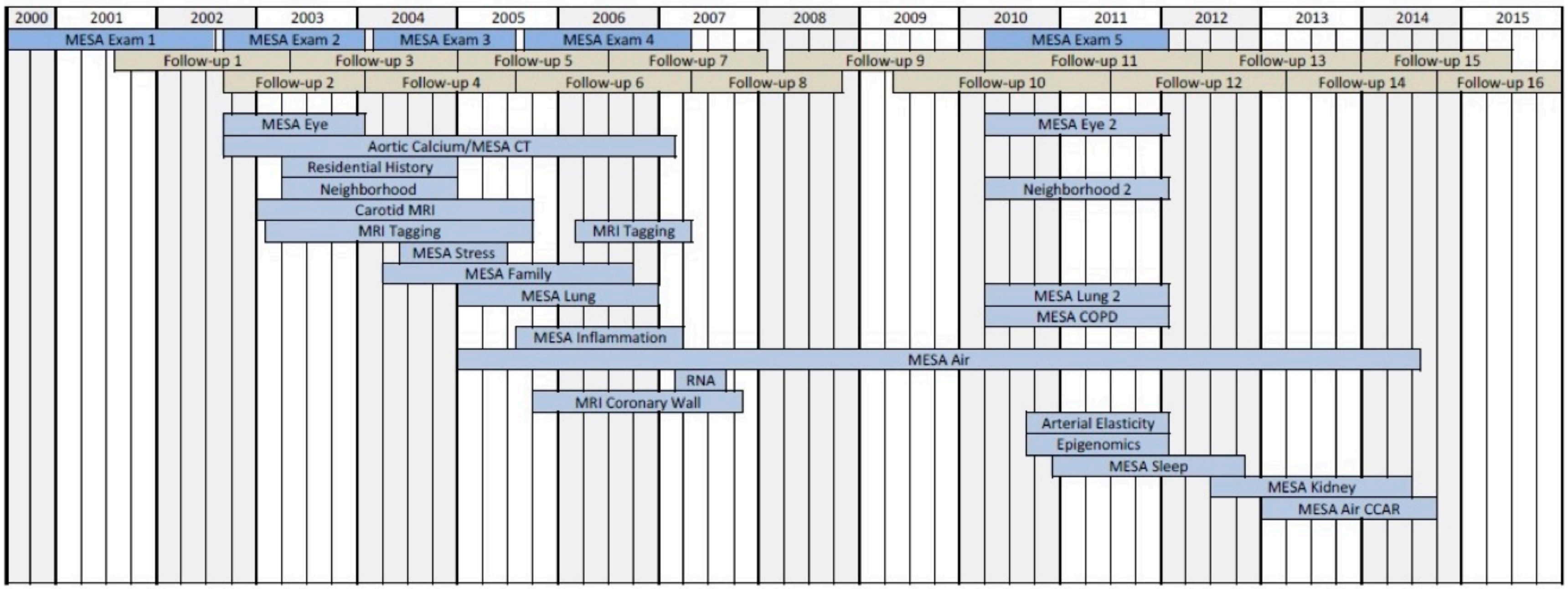
CHAPTER 3: METHODS

3.1. DATA SOURCE

3.1.1. THE MULTIETHNIC STUDY OF ATHEROSCLEROSIS

The Multiethnic Study of Atherosclerosis (MESA) was designed to study the characteristics related to the progression of subclinical to clinical cardiovascular disease.[1] Four ethnic groups were represented – African American or Black (28%), Chinese-American (12%), Hispanic (22%), and Caucasian or White (38%). The study was designed to be multiethnic due to the common disparities in risk factors for cardiovascular disease such as higher rate of hypertension in Blacks, higher rates of obesity and diabetes in Blacks and Hispanics, higher levels of risk factors but lower levels of clinical disease in Hispanics, and lower morbidity and mortality in Pacific Asians. Participants of MESA come from six field centers across the U.S.: Forsyth County, NC (Wake Forest); Northern Manhattan and the Bronx NY (Columbia); Baltimore City and Baltimore County, MD (Johns Hopkins); St. Paul Minnesota (Twin Cities); Chicago, IL (Northwestern); and Los Angeles County, CA (UCLA). In all, 6814 participants were enrolled. Although the cohort is community based, sampling methods varied by site based on the recruitment targets. In Wake Forest, Columbia, and Northwestern, random sampling stratified by age and gender was utilized. In Minnesota and Johns Hopkins, sampling was conducted along geographic lines rather than by demographic characteristics and sampling in UCLA employed random digit dialing. Ages ranged from 45 to 84 years with similar numbers of men and women. The first examination took place over 2 years from July 2000-July 2002 followed by exams 2, 3, and 4, which occurred at 17-20 month intervals. Exam 5 occurred from April 2010 – January 2012 Figure 1). Participants were contacted by phone every 9-12 months to assess clinical morbidity and mortality [1]. MESA has multiple ancillary studies such as MESA Sleep, MESA Lung, MESA Air Pollution, and MESA Stress. MESA Stress[2] is the ancillary study from which the sample for aim 1 will be drawn.

Figure 3.1. MESA Calendar of Exams, Follow-up Calls, and Ancillary Studies



3.1.2. SAMPLE FOR AIM 1

The sample for aim 1 came from the the MESA Stress ancillary study. The MESA Stress study was an ancillary study that included a subsample of 1001 participants who enrolled at the New York and Los Angeles study sites. In the sub-study, investigators collected measures of stress hormones between 2004 and 2006 in conjunction with the third and fourth follow-up exams of the full MESA cohort. Participants were enrolled in the order they presented for their follow-up exams, with enrollment being ongoing until about 500 participants were enrolled at each of the NY and LA study sites. Overall, the participants in the Stress study are similar to those in the full MESA cohort with the exception of fewer persons in the 75-84 year age range (12.1% compared to 18.2% in the overall MESA study), slightly more men (47.6% compared to 44.7%) and more participants with some college education (29.7% compared to 23.9%).[3] While statistically significant, these differences were small.

3.1.3. SAMPLE FOR AIM 2 AND AIM 3

The sample for aim 2 came from the MESA parent study. We used all participants who had full cognitive functioning, allostatic load, discrimination, health behaviors, and covariate data. The reason for the addition to the sample is described in the statistical modeling section of the methods for aim 1 below. The sample for aim 3 was similar to the sample in aim 2 except cognitive functioning wasn't a variable so participants had to have full allostatic load, discrimination, health behaviors, and covariate data. The available sample size for aim 2 was 4591 (the actual sample size depended on which cognitive test was being used as the outcome and ranged from 3935 for Total Cognition to 4423 for the Digit Span Total) and the sample size for aim 3 was 4138.

3.2. MEASUREMENT ISSUES

3.2.1. RACE

Race, though often measured and analyzed in public health research, is a nebulous variable in research. Many papers and commentaries regarding the measurement of race, both by the government through the census and by public health and medical researchers, have entreated would-be race researchers to take special care when defining race and to recognize that race is often a proxy for other variables that go unmeasured. Although some researchers have advocated for the removal of race as a research construct and on government documents, the vast majority recognize that research involving race has led us to important discoveries that have helped to better understand health disparities. Etiology of disease for instance has been a great contribution of race research in the form of differing incident rates and modifiable factors.[4] Currently, when race is collected it is often done to describe vital and health statistics, as a risk indicator for health outcomes, to improve the delivery of health services, as a marker for unmeasured biological differences, and as a proxy for unmeasured social factors.[5]

Scientific research has long since shown that race is in fact a social construct that appears to be ever-changing. Genetic research on race has revealed that there are is in fact more heterogeneity within races than between races indicating that racial differences are more likely to be due to other factors such as social factors than they are to biological factors. Calls have been made to deconstruct the idea of race and disentangle it from socioeconomic status which it most often tends to represent in social research.[6, 7] Indeed, measures of disease and health habits among races in mixed neighborhoods tend to correspond to the incidence of disease and common health habits of the predominant race in the neighborhood. So that in a poor neighborhood that is predominately black, whites who live in that neighborhood have a more similar risk for disease and health habits as blacks than among the general population.[5, 8]

In the context of measuring racial differences in cognitive functioning through neuropsychological testing, deconstructing the idea of race is especially important. Factors such as quality of education, literacy, cultural experience (acculturation among both immigrant and native minorities), and race socialization (beliefs about one's own racial identity and the racial identity of others) are associated with results on these tests so research with these outcomes must include the caveat that they may be measuring more than just racial differences per se.[6] Oftentimes including just education, or just socioeconomic status is not adequate in controlling for the effect that these variables may have on associations between race and outcomes. Measures of wealth and financial security have been found to be significant predictors of health issues as Whites tend to have vastly more wealth and financial security than blacks and Hispanics even when annual income is the same.[7] Studies have shown that even within socioeconomic classes, race/ethnicity associated health disparities still exist.[9] These may be accounted for by quality of education, environmental factors, neighborhood factors, and so on. Racism, through neighborhood segregation, inferior education quality, and accumulation of wealth, also appears to exert a profound influence on associations between race and health outcomes especially. Therefore, it is important to recognize that race, an important aspect of research, is most useful when it is measured accurately (by self-report of both race and ethnicity) and when the researcher is aware of what else it may be measuring. Recommendations for improving race-related research include – improving measures of ethnicity beyond only Hispanic and non-Hispanic, recognizing that self-identified race may change within individuals over time depending on social and political climate, deconstructing race to it's previously mentioned components, including lifetime socioeconomic status and changes therein, including measures of social class at both the individual and neighborhood levels, inclusion of measures of racism, and educating researchers and practitioners to recognize that factors such as geographical segregation can assert an effect on health disparities.[4-7]

3.2.2. ALLOSTATIC LOAD

Current challenges of using allostatic load (AL) include the best way to measure it and a better understanding of the types of stress that can increase it [10]. Measurement of AL has been largely dependent upon the biological measures available. With no standard way to compute AL, multiple methods have been employed including total score,[11, 12] recursive partitioning,[13] confirmatory factor analysis,[14] latent growth mixture modelling,[15] and latent profile analysis.[16] Total score is the most common method found in the literature and usually consists of assigning a '1' to an indicator if above a threshold that would be considered "high risk" and '0' otherwise and summing for a total AL score. System sub-scores can also be used with common systems including metabolic, cardiovascular, hypothalamic-pituitary-adrenal, sympathetic, parasympathetic, and inflammatory. Among the most commonly used biological indicators are systolic and diastolic blood pressure, HbA1c, high density lipoprotein cholesterol, low density lipoprotein cholesterol, and body mass index – all of which are also implicated in development of cardiovascular disease.

3.3. APPROACH TO MEASUREMENT

3.3.1. RACE

For the current study we used the self-reported measures of race and ethnicity that were available in the Multiethnic Study of Atherosclerosis. In addition to race we created a variable for socioeconomic disadvantage that, rather than solely measuring education or income, included measures of wealth such as owning or renting and measures of health advantage such as availability and type of health insurance in addition to education. We also included in our socioeconomic disadvantage variable, a household adjusted income and created poverty-to-income ratio groups in order to distinguish between those carrying excessive financial burden, similar to other studies.[17]

3.3.2. ALLOSTATIC LOAD

We took two approaches to measuring allostatic load in the current research. In the first aim we represented allostatic load through latent class analysis of common biological indicators of allostatic load. When further analysis revealed that this more complicated definition of allostatic load was not a better predictor of either cognitive functioning or health behaviors (details included below under "Aim 1" we chose to use a less complicated method that has been utilized in the MESA population in previous research. This method was used by Merkin et al[18] and involved creating a total allostatic load score based on z-scores that determined how far a person was (in SD) from predetermined clinical cut-offs. The z-scores were summed to create a total allostatic load score.

3.4 METHOD SYNTHESIS

Taking into account the information above regarding measurement issues we used a variety of methods to capture the relationship between allostatic load, cognitive function, discrimination, and health behaviors.

3.4.1. AIM 1: LATENT CLASS ANALYSIS AND LATENT CLASS REGRESSION

Aim 1: Empirically identify groups of adults with different patterns of biological indicators of allostatic load and investigate the relationship between health behaviors (smoking, drinking, exercise, and diet) and allostatic load.

Statistical Modeling.

The first step in latent class analysis (LCA) is to specify the measurement model. We began by creating a measurement model using the biological indicators of allostatic load. The first step in creating the correct measurement model was to run models with class numbers varying from two to six. We stopped at six because there were eleven total indicators and six was roughly half the number of indicators. Fit statistics, AIC, BIC, Bootstrapped Likelihood Ratio Test, and the Lo-Mendell-Rubin test[19], were compared for each of these models to determine the model that best fit the dataset. Identifiability, whether or not the parameters have unique interpretations was testing by using the equation "$(J*M) + (J-1) \leq 2^M - 1$" where J = number of classes and M = number of indicators. We checked the estimability (is the dataset 'rich' enough to estimate the parameters) by looking for empty or low count cells. We also checked the boundary values to ensure that local maxima were not reached.

The primary assumption of latent class analysis is that after conditioning on the latent variable, the observed indicator variables are independent of one another.[20] The conditional independence assumption was tested by comparing the observed and expected standardized bivariate residuals under the observed and the independent models. Since the counts were not significantly different, we concluded that the conditional independence assumption was met. Once the main assumption has been met the researcher must use fit statistics to decide if the model is a good fit to the data. Fit statistics used in LCA include information criteria (AIC & BIC) which are a function of the log likelihood, though the BIC performs better than the AIC in LCA.[19] The goal is to have smallest AIC and BIC possible; likelihood ratio tests such as the Lo-Mendell Rueben and Bootstrapped Likelihood Ratio test indicate if a model with less classes is a better fit to the data than the model with 1+that number of classes (e.g. comparing a 3-class model to a 4-class model). Entropy measures classification error and ranges from 0-1 with values closer to 1 being desirable for acceptable model fit.

When covariates are added to the model the researcher has the option of using the 1-step method or the 3-step method.[21] The 1-step method involves re-estimating the measurement model each time a covariate is added because the structural and measurement portions of the model are measured jointly. This method has often been considered problematic because the class structure may change when covariates are added. The 3-step method involves estimating the measurement model, using posterior probabilities to assign classes, and then regressing classes onto the covariates, essentially treating class assignment as an observed variable. However, since class is not actually an observed variable this method can introduce bias and underestimate standard errors.[22] In order to account for this bias we used a corrected 3-step method where we set each class at its logit for classification probability.[23]

Finally, we created receiver operating characteristic (ROC) curves in order to determine if our latent class definition of allostatic load was a better predictor of the overall research outcome of cognitive function and the health behaviors than less complex versions of allostatic load (e.g. dichotomized low/high, total score based on number of indicators labeled "high", and total z-score based on standard deviations from clinical cut-points). ROC curves show the sensitivity plotted against 1-specificity for a given predictor and or set of predictors. The area under the ROC curve (AUC) is a measure of discrimination jointly maximizes sensitivity and specificity. We found that our latent measure of allostatic load did not predict health behaviors or cognitive function any better than less complex measures. Therefore, we opted to use a less complex measure that was available in the parent study rather than solely in the Stress sub-study, thus increasing our sample size for the final two aims.

3.4.2. AIM 2: PATH ANALYSIS

Aim 2: Determine the relationship between allostatic load and cognitive function across self-identified ethno-racial groups as a function of experiences of perceived discrimination and poor health behaviors.

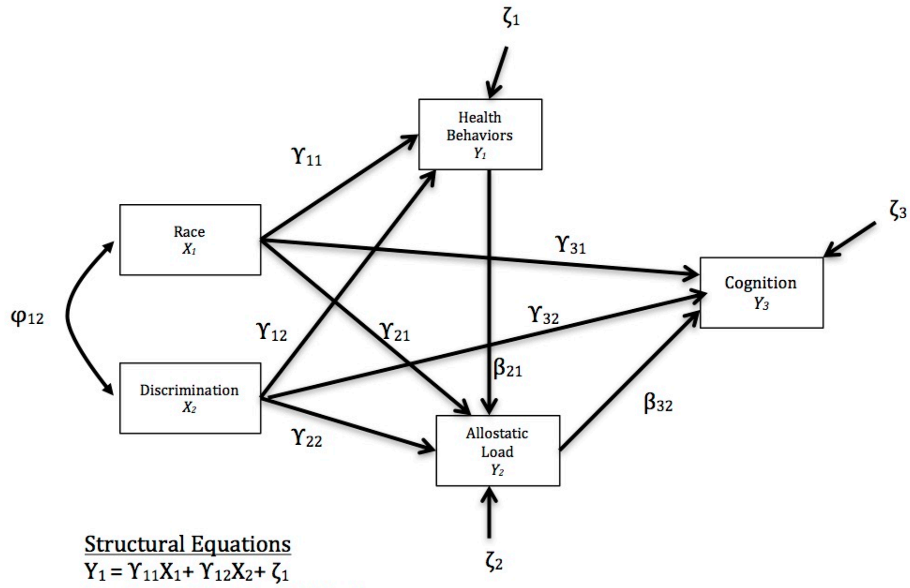
Statistical Modeling

Path analysis is a special form of structural equation modeling that deals exclusively with manifest (observed) variables. Path analysis is an extension of multiple linear regression that is more flexible in model specification and allows the researcher to specify variables as both dependent and independent simultaneously which is not available in traditional multiple linear regression. In addition, path analysis has the capability to estimate all of the hypothesized relationships simultaneously which is beneficial when complex relationships are being estimated. The main assumptions of path analysis are: dependent variables do not co-vary, there should be no residual error for purely independent variables (those that are modeled only as independent), and relationships between variables are linear. Path analysis solves a system of structural equations (Figure 1) and the relationships that these equations represent are predominately driven by theory in that the researcher should already have evidence that variables have shown an association with one another.

Before fitting a path model identifiability must be tested. Identifiability is tested in 3 ways – the T-Rule (necessary but not sufficient) which compares the number of unknown parameters to the number of unique observed variances and covariances to be estimated; the Null B Rule which states that no endogenous (dependent) variable affects any other endogenous variable; and the Recursive Rule which states that there can be no reciprocal causation or correlated errors. After identifiability is confirmed the model can be fit. Fit statistics for path analysis include the Chi-Square test, the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), the Root Mean Square Error of Approximation (RMSEA), the comparative fit index (CFI), and the Tucker Lewis Index (TLI).

The Chi Square test evaluates the hypothesis that the estimated model is equal to the saturated model (model where the number of unknown parameters is equal to number of unique observed variances and covariances). This test should fail to reject the null (that the model is not equal to the saturated

Figure 3.2. Path model of proposed relationships between race, discrimination, allostatic load, health behaviors, and cognitive function and corresponding structural equations



<u>Structural Equations</u>

$Y_1 = \Upsilon_{11}X_1 + \Upsilon_{12}X_2 + \zeta_1$

$Y_2 = \Upsilon_{21}X_1 + \Upsilon_{22} + X_2 + \beta_{21}Y_1 + \zeta_2$

$Y_3 = \Upsilon_{31}X_1 + \beta_{32}Y_2 + \Upsilon_{32}X_2 + \zeta_3$

model). Previous literature has shown, however, that when a large sample size is used the Chi Square test tends to show rejection of the null hypothesis regardless of the true model fit.[24] The AIC and BIC are both relative fit statistics and smaller values indicate better fit. The RMSEA is based on the approximated covariance matrix where 0 is a perfect fit, so values closest to zero indicate better fit. The goal value for RMSEA is less than 0.05. The CFI and TLI compare the model to the independence model (a model where all variables are uncorrelated) and the goal for both is 0.95 or higher.[24]

After model fit is examined and a model is accepted the researcher must use judgment to determine what paths can be removed to create the most parsimonious model possible. Non-significant paths are often removed unless there is strong theoretical support that the path should remain in the model.

3.4.3. AIM 3: LINEAR REGRESSION WITH INTERACTION

Aim 3: To assess the association of coping style and social support with the relationship between perceived discrimination and allostatic load.

Statistical Modeling

Allostatic load at baseline and change in allostatic load from exam 1 to exam 5 were normally distributed and linear. Normality was assessed based on observation of a Quantile-Normal plot and linearity was assessed by inspecting a scatter plot of residuals versus fitted values. The measure of chronic discrimination (Daily Hassles Questionnaire) was positively skewed due to the preponderance of participants who reported never having experienced chronic discrimination or having experienced very little chronic discrimination. In order to deal with this, we categorized amount of chronic discrimination to “none”, “low”, and “some” based on the likert-type answers in the questionnaire. Social support was negatively skewed due to most participants reporting having social support available. Since less than 1% of the sample reported having no social support available we created “high” and “low” categories based on the the questionnaire responses and included those who reported no social support in the “low” category.

In order to assess moderation of the relationship between chronic discrimination and allostatic load by coping style, we conducted multivariable linear regression with interaction terms. The main assumptions of multiple linear regression are: a linear and additive relationship between the outcome and the predictors, statistical independence of observations, homogeneous dispersion, and normality of the outcome. We tested each of these assumptions in turn to ensure that linear regression was an appropriate statistical measure for this data.

We tested the linearity and additive assumptions by creating scatter plots of the residuals versus fitted values and box plots of the residuals versus each of the predictors, due to the predictors being categorical. In the residual versus fitted value plots, we found that there was general symmetry about the reference line indicating a linear relationship. Among the box plots of residuals within each level of the predictors we found that the boxes were evenly spaced among each level and appeared to show a linear relationship. The independence assumption was met based on the randomization methods used during data collection. To test the homogeneity assumption, that the variances of the error terms are constant throughout and don't change based on the fitted values, we again scrutinized a residual vs. fitted values plot as well as residual vs. fitted plots at each level of the predictors and found some evidence for heteroskedasticity in certain models. For those models we conducted a more formal test of heteroskedasticity, the Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. The null hypothesis for this test is that the error terms have constant variance. We found that for the questionable models there was evidence that the hypothesis of constant variance should be rejected, thus we employed robust standard variances, which allow for the presence of heteroskedasticity. Finally, we tested the normality assumption with a quantile-normal plot which compares the the distribution of the data values with an expected normal distribution. We did not find any evidence that our data violates the normality assumption.

After we decided that linear regression was an appropriate statistical method for this data we added interaction terms to test moderation. Interaction terms allow the researcher to look at the outcome at different levels of multiple predictors. We created interaction terms between discrimination and each of the coping styles as well as between discrimination and social support.

3.5. RESEARCH ETHICS

This dissertation was completed using de-identified secondary data. The proposal was reviewed by the Johns Hopkins Internal Review Board (IRB) and was designated as not human subjects research. All data obtained from the Multiethnic Study of Atherosclerosis was done so through a secure, one-time use, password protected link. In secondary data analysis research, the researcher must rely on documentation from the original data collection to ensure that it was conducted in an ethical manner. The Multiethnic Study of Atherosclerosis (MESA) carefully documented each step of their data collection. Each participant signed a consent form to participate and were ensured that their information would be protected under privacy laws. All participants were identified with personal identifiers so as to protect their personal data. Participants were informed that: 1. The only people who would know that they were participants in the study were members of the research team, and their physician, if appropriate; 2. Individual identifying information about them would not be disclosed to others, except where required by law; and 3. All published results would be de-identified to protect participant's privacy. MESA also did and continues to do regular quality assurance checks. Each field center is in regular contact with the main coordinating center in order to resolve any issues with data that should arise.

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CHAPTER 4. THE ASSOCIATION BETWEEN ALLOSTATIC LOAD AND HEALTH BEHAVIORS: A LATENT CLASS APPROACH

4.1. ABSTRACT

Allostatic load (AL) has been characterized in many ways throughout the literature however its relationship to health behaviors has only been studied in limited populations. We conducted latent class analysis using biological indicators from a multi-ethnic population. Four classes, featuring varying degrees of each indicator, were found in the sample. We fit latent class regression of class on health behaviors (smoking, diet, physical activity, and alcohol use) to see if any of the latent classes of AL were associated with health behaviors. We found that physical activity and alcohol use were significantly associated with one of the latent classes of AL. Implications regarding the amount of physical activity needed to prevent increased AL are discussed.

4.2. INTRODUCTION

Allostatic load (AL) is the cumulative biological toll on the body due to prolonged chronic stress.[1] In recent years AL has become a popular mechanism for studying the toll of stress on multiple bodily systems. Some of the challenges of using AL include the best way to measure it and a better understanding of the types of stress that can increase it.[2] Measurement of AL has been largely dependent upon the biological measures available. With no standard way to compute AL, multiple methods have been employed including total score,[3, 4] recursive partitioning,[5] confirmatory factor analysis,[6] latent growth mixture modelling,[7] and latent profile analysis.[8] Total score is the most common method found in the literature and usually consists of assigning a ‘1’ to an indicator if above a threshold that would be considered “high risk” and ‘0’ otherwise and summing or averaging for a total AL score. System sub-scores can also be used with common systems being metabolic, cardiovascular, hypothalamic-pituitary-adrenal, sympathetic, parasympathetic, and inflammatory. Among the most commonly used biological indicators are systolic and diastolic blood pressure, HbA1c, high density lipoprotein cholesterol, low density lipoprotein cholesterol, and body mass index – all of which are also implicated in development of cardiovascular disease. We aimed to uncover possible qualitative differences in patterns of biological indicators of AL that may not be evident when the indicators are simply added together to create a total score. We utilized latent class analysis because it identifies underlying patterns in the sample based on dichotomous indicators.

Regardless of the way AL is measured it has been shown to be influenced by socioeconomic status, perceived stress, and level of education.[4, 9-12] Although these associations are well known, less is known about how health behaviors (e.g. diet, physical activity, smoking, and alcohol use) are associated with AL. These health behaviors are associated with some of the individual biological indicators of AL. For example, cigarette smoking is known to be associated with the risk of cardiovascular disease, atherosclerosis, peripheral artery disease, high blood pressure, stroke, and decreased high-density lipoprotein (HDL) cholesterol.[13-16] Regular physical activity is known to decrease the risk of cardiovascular disease in general by decreasing the risk of metabolic syndrome and stroke, increasing HDL cholesterol while reducing low-density lipoprotein (LDL) cholesterol, and helping to control weight.[17, 18] Studies have also shown that physically active individuals tend to have lower systolic diastolic blood pressure and lower glucose and HbA1c compared to those who are not active.[19] Recommendations for a healthy diet, such as intake of fruits and vegetables and lean meats, and reduction in trans fats and added sugars, can help to control weight and by extension help lower risk for cardiovascular disease. Alcohol use can be both positive and negative depending upon the type and amount consumed. Healthy moderate drinkers have been shown to have a lower risk of heart disease and stroke than those who drink heavily or do not drink at all, while heavy drinking has been shown to cause heart-related problems such as increases in blood pressure and triglycerides.[20]

Although health behaviors are clearly associated with certain indicators of AL, their association with AL is poorly understood. Recently, a few studies have shown an association between AL and poor diet[21] and between AL and physical activity[22-24] in specific populations. However, more often than not these behaviors are simply included as variables in a model testing the relationship between AL and another outcome (e.g. socioeconomic status).[12, 25-28]

Making health behaviors the focus of the analysis rather than just including them as confounders, may allow us to better understand how these modifiable risk factors are associated with AL as a construct. We used latent class analytic models in order to determine if there were clusters of AL indicators within the sample and to explore the relationship between latent class of AL and common health behaviors such as smoking, alcohol use, diet, and physical activity. We were interested in how health behaviors were associated not only with AL as a whole, but how specific health behaviors might influence components of the AL construct. We hypothesized that qualitatively different classes of AL would be found and that health behaviors would be associated with cardiovascular and metabolic patterns.

4.3. METHOD

4.3.1. PARTICIPANTS

The sample was derived from the Stress sub-study of the Multiethnic Study of Atherosclerosis (MESA). The parent study, MESA, consisted of 6,814 healthy male and female volunteers who reported their race/ethnicity as White, African American, Hispanic, or Asian. The volunteers were recruited from six study centers in various states throughout the US (NC, NY, MD, MN, IL, and CA). There were five examinations total between 2000 and 2012. The MESA Stress ancillary study was conducted between 2004 and 2006 in conjunction with exams 3 and 4 of the parent study. One thousand and two participants were enrolled in MESA Stress from the New York and Los Angeles study sites. Participants were enrolled in the order in which they came for their follow-up exams until about 500 were enrolled at each site. The MESA Stress participants are similar to the full cohort with the exception of fewer persons in the 75-84-year age category, slightly more men, and more participants with some college education.

4.3.2. MEASURES

Allostatic Load. Twelve physiological indicators (resting heart rate [RHR], systolic blood pressure, diastolic blood pressure, waist-to-hip ratio [WHR], body mass index [BMI], low density lipoprotein [LDL] cholesterol, high density lipoprotein [HDL] cholesterol, glucose, total cholesterol, cortisol, norepinephrine, epinephrine) that were collected at the MESA Stress Exam (between exams 3 and 4) were used to construct allostatic load (AL). The indicators represented various bodily systems – metabolic, cardiovascular, hypothalamic pituitary axis, sympathetic, and parasympathetic. Participants were given a point for each indicator for which their score was in the top 25% of the sample distribution with the exception of HDL cholesterol, which was for the lower 25% of the sample distribution. Waist-to-hip ratio was sex-specific. We calculated the top 25% within each sex and anyone above that cut-off for each sex was given a "1" for WHR. We then created a variable which included both sexes from the sex-specific variables. Some researchers choose to put those on medications in the high-risk category[9, 29] and some choose to disregard medication use and assign participants based on their current values.[30] Due to the chronic nature of AL and the large age range of the sample we decided to include those who were on medications (lipid lowering, hypertension, oral hypoglycemic, insulin, beta blockers, and ACE inhibitors) as high-risk since there may have been damage to various bodily systems prior to beginning medication.

Health Behaviors. Health behaviors were defined as smoking, drinking alcohol, physical exercise, and diet and were reported at exam 1. Smokers were those who indicated that they currently smoke as opposed to never smoked or smoked formerly. Alcohol drinkers were those who indicated that they currently drink alcohol as opposed to never drank alcohol or formerly drank alcohol. Physical activity was defined as reporting 500 or more metabolic equivalent tasks (METs) minutes per week of intentional exercise (e.g. walking, dancing, sport, conditioning). MET minutes are defined by multiplying the number of METs expended in an activity by the number of minutes performed each week (e.g. for vigorous activity such as running the minimum number of METs per minute is 6, so a person who does vigorous running 4 times a week for 30 minutes would have 720 MET-minutes per week from running). METs levels are determined by the Office of Disease Prevention and Health Promotion guidelines. We chose the threshold of 500 MET-minutes based on the recommendations of the the Office of Disease Prevention and Health Promotion for adults.

Poor diet was modeled with two empirically derived variables. Diet data was collected using the Food Frequency Questionnaire (FFQ). Previous MESA authors who conducted the ancillary diet study created food groups based on the FFQ.[31] Principle components analysis was done on the food groups in order to determine the number of factors that best represented the eating habits of the sample. The factor analysis resulted in four factors that best represented the eating habits of the sample. Two factors were considered “poor diet” (sweets and soda; fats, oils, and fried foods) and two factors were “healthy diet.” For this analysis we used only the poor diet factors. Those who had factor scores in the top 25th percentile for each poor diet factor were considered to have a poor diet. Sex, years of education, age, race were self-reported.

4.3.3. STATISICAL ANALYSIS

Latent class analytic models were estimated with 12 dichotomous biological indicators to find clusters of allostatic load indicators. We compared AIC, BIC, Entropy, Lo-Mendell-Rubin, and Bootstrapped Likelihood ratio tests for models with 2-6 classes.[32] One of the main assumptions of LCA is that after conditioning on the latent variable,[33] indicators are independent of one another. In order to check this assumption, we compared observed standardized bivariate residuals to those expected from the model under the assumption of independence. We found that most residuals were within normal limits but there were a few that were larger than preferred. In order to address this, we collapsed some variables that were highly correlated (BMI and WHR; LDL cholesterol and total cholesterol; and norepinephrine and epinephrine). We then re-ran the LCA with these combined indicators and found that the best fitting model (based on standardized bivariate residuals) was one that included the cholesterol combination and norepinephrine/epinephrine combinations. We also excluded resting heart rate as an indicator because 99% of the sample had a RHR of less than 100 so it did not discriminate between classes well. The final model included nine indicators - systolic blood pressure, diastolic blood pressure, body mass index, waist-to-hip ratio, glucose, cortisol, combination 2 (LDL cholesterol and total cholesterol) and combination 3 (norepinephrine and epinephrine).

After the four class model was selected we fit latent class regression of class on health behaviors using the corrected 3-step method.[34] We conducted regressions with individual health behaviors predicting class and multivariate models in which health behaviors were added one at a time. We regressed class membership on demographic variables and found that sex, education, race, and age category were significantly associated with class membership so all models controlled for these variables. Descriptive statistics were conducted in Stata 13 [35] and all latent variable models were completed in MPlus v7.1.[36]

4.4. RESULTS

4.4.1. SAMPLE

Table 1 provides descriptive statistics for the sample. The sample was comprised of 1002 participants who were enrolled in the the Mesa Stress ancillary study. Of the 1002 participants, 53% were women, 29% were black, and 53% were Hispanic. Twenty percent had at least a high school education or GED while 11% had bachelor's degree. The majority of the sample (64%) were between 55 and 74 years of age. Twenty-seven percent of the sample was on lipid lowering medications while nearly half of the sample (48%) was on some type of hypertension medication. Three percent of the sample was missing cortisol, norepinephrine, and epinephrine. No participants were missing more than three indicators out of eleven and since the number missing was small, we used all of the available data to estimate AL.

4.4.2. AL CLASSES

Figure 1 shows the conditional probabilities for each indicator by class. We labeled class 1 "Metabolic + Cholesterol" (17% prevalence) because it featured high rates (>40%) for waist-to-hip ratio, body mass index, high density lipoprotein cholesterol, glucose, and combination 2 which indicates either total cholesterol in the top 25% of the sample distribution or low density lipoprotein cholesterol in the top 25% of the sample. The second class was labeled "Blood Pressure" (14% prevalence) because it featured high rates of systolic blood pressure and diastolic blood pressure. The third class was labeled "Metabolic + Blood Pressure" (36% prevalence) because it included high rates of systolic blood pressure, diastolic blood pressure, waist-to-hip ratio, body mass index, and glucose. The final class was labeled "low" (34% prevalence) because it featured low rates of all physiological indicators.

4.4.3. PREVALENCE OF HEALTH BEHAVIORS

Eleven percent of the sample reported being current smokers while 36% reported being former smokers. Fifty-four percent of the sample reported current alcohol use. Twenty-seven percent of the sample said that they got zero Met-min of intentional exercise per week. The mean factor scores of the healthy diet patterns were more than twice as high as those of the unhealthy diet patterns indicating that overall diet was not necessarily poor.

4.4.4. AL CLASS AND HEALTH BEHAVIORS

Individual health behavior models. When class membership was regressed on individual health behaviors, controlling for demographic variables, the "metabolic + blood pressure" class was the only class that showed significant associations with any of the health behaviors (see table 2). Those having more than 500 MET-minutes of exercise per week were significantly less likely to be in the "metabolic + blood pressure" class compared to the "low class" (odds ratio (OR) = 0.61; 95% confidence interval (CI): 0.41-0.92). Similarly, those who endorsed current alcohol use were less likely to be in the "metabolic + blood pressure class" (OR = 0.63; 95% CI: 0.41-0.95) compared to the "low class." Diet and smoking were not significant predictors of any of the AL classes.

Full models. When all of the health behaviors were included in the model the results were similar to the individual models, with physical activity and alcohol use still the only two health behaviors that were significantly associated with class (see table 3). The odds ratio for physical activity in class 3 compared to class 4 increased slightly from the individual model (0.61 [95% CI: 0.41 – 0.92]) vs (0.63 [95% CI: 0.42 – 0.96]) and the odds ratio for alcohol use in class 3 compared to class 4 remained the same (0.63 [95% CI: 0.41 – 0.95]) vs. 0.63 [95% CI: 0.40 – 1.00]).

Table 4.1. Allostatic Load Indicators by Percentile, Sample Demographics, and Health Behaviors in the Multi-ethnic Study of Atherosclerosis Stress Sub-study, 2004-2005

Variables	**25th percentile**	**Mean**	**75th percentile**
a. Allostatic Load			
Resting Heart Rate	57.50	64.50	71.00
Systolic Blood Pressure	108.50	123.40	136.00
Diastolic Blood Pressure	63.50	69.88	76.50
Waist-to-hip-ratio (in)			
Male	0.93	0.98	1.02
Female	0.87	0.92	0.98
Body Mass Index	25.20	29.04	32.0
Low Density Lipoprotein Cholesterol	91.00	113.43	133.00
High Density Lipoprotein Cholesterol	41.00	51.33	59.00
Glucose	88.00	102.68	105.00
Total Cholesterol	166.00	190.04	211.00
Cortisol (ng/ml)	5.51	12.00	21.80
Norepinephrine	11.50	15.29	21.14
Epinephrine	0.86	1.36	2.22

Variables	**n**	**%**	**Total**
b. Demographics			
Age Categories			
45-54	170	17	
55-64	310	31	1002
65-74	333	33	
75-84	189	19	
Female Sex	526	53	
Race			
White, Caucasian	188	19	
Black, African American	286	29	1002
Hispanic	528	53	
Education			
High school/GED	202	20	
Bachelor's degree	111	11	
c. Medications			
Any lipid lowering med	261	27	980
Any hypertension meds	466	48	980
Oral hypoglycemic	125	13	980
Insulin	24	2.5	980
d. Health Behaviors			
Physical Activity (>=500 METS per week)	587	59	1002
Smoker (current)	113	11	1002
Alcohol (current)	538	30	1001
Poor Diet – Sweets and Soda	269	27	1002
Poor Diet – Fats, Oils, Fried Foods	271	27	1002

Figure 4.1. Conditional probabilities (y-axis) for each biological indicator (x-axis) by class with confidence intervals. Multi-ethnic Study of Atherosclerosis Stress Sub-study (2004-2005)

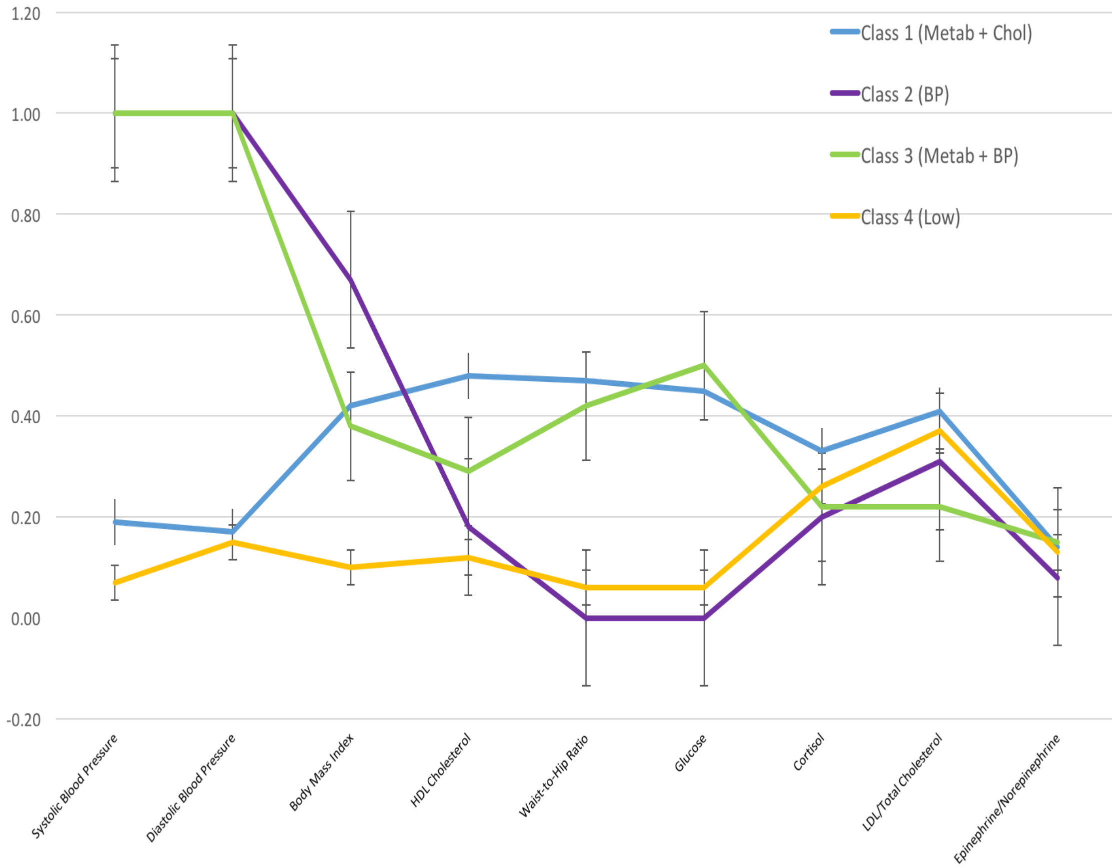

Table 4.2. Odds Ratios and 95% Confidence Intervals from Latent Class Regression Models of Allostatic Load Class on Individual Health Behaviors

	Physical Activity[a]	Diet_FOF	Diet_SS	Alcohol	Smoking
Class 1 "Metabolic + Cholesterol"	0.78 (0.41-1.47)	1.02 (0.50-2.09)	1.51 (0.33-3.04)	0.90 (0.46-1.75)	2.70 (0.76-9.60)
Class 2 "Blood Pressure"	1.73 (0.91–3.31)	0.82 (0.35-1.26)	0.82 (0.43-1.56)	1.82 (0.92-3.61)	1.26 (0.44-3.57)
Class 3 "Metabolic + BP"	0.61 (0.41-0.92)	0.75 (0.47-1.20)	0.85 (0.52-1.38)	0.63 (0.41-0.95)	1.74 (0.79-3.79)
Class 4 "Low" (reference)	1.00	1.00	1.00	1.00	1.00

[a]All models in the table controlled for age, sex, race, education
Diet_FOF = Diet - Fats, Oils, Fried Foods
Diet_SS = Diet - Sweets, Soda

Table 4.3. Odds Ratios and 95% Confidence Intervals from Latent Class Regression Models of Allostatic Load Class on Health Behaviors Controlling for Other Health Behaviors.

	Physical Activity[a]	Diet – FOF	Diet – SS	Alcohol	Smoking
Class 1 "Metabolic + Cholesterol"	0.80 (0.40-1.59)	0.65 (0.28-1.49)	2.07 (0.90-4.73)	0.86 (0.37-2.01)	3.05 (0.75-12.49)
Class 2 "Blood Pressure"	1.77 (0.89-3.55)	0.57 (0.28-1.16)	1.05 (0.50-2.21)	1.86 (0.94-3.68)	1.42 (0.48-4.16)
Class 3 "Metabolic + BP"	0.62 (0.42-0.96)	0.75 (0.44-1.30)	1.09 (0.61-1.97)	0.63 (0.40-1.00)	1.86 (0.85-6.40)
Class 4 "Low" (reference)	1.00	1.00	1.00	1.00	1.00

[a]All models in the table controlled for age, sex, race, education
Diet_FOF = Diet - Fats, Oils, Fried Foods
Diet_SS = Diet - Sweets, Soda

4.5. DISCUSSION

We found that in a multi-ethnic sample, biological indicators of allostatic load could be separated into four clusters and that the metabolic plus blood pressure class was significantly associated with physical activity and alcohol use. We believe that the results support the idea that a moderate amount of exercise and a low to moderate amount of alcohol can be beneficial to the reduction of metabolic risk factors.

Using latent class analysis, we found four clusters of participants with patterns of biological indicators within the sample; namely, a metabolic plus cholesterol class, a blood pressure class, at metabolic plus blood pressure class, and a low class. Although there are many ways to measure allostatic load, factor and latent measures are gaining popularity. Recently, Buckwalter and colleagues[37] used a case-based computational modeling approach in which they conducted factor analysis and then used the factors to create clinical profiles of AL. Although they had more biomarkers available their clinical profiles did show some similarities to the clusters we found using LCA including individual profiles for high blood pressure and metabolic syndrome. McCaffery et al also conducted a factor analysis using biological indicators of AL to differentiate AL from metabolic syndrome and found that there were distinctly different factors representing AL and metabolic syndrome.[6] Although one of our clusters is similar to metabolic syndrome we found 3 other clusters that were distinctly different from metabolic syndrome.

Physical activity was related to at least one cluster of AL in our sample. Those who got at least 500 MET-minutes of intentional physical activity per week were significantly less likely to be in the metabolic plus blood pressure class than in the low class. Xue et al observed that women who are physically active don't have to be highly active to benefit from exercise.[38] Even those women who had the lowest levels of physical activity had better mortality rates than those who were sedentary. This finding in addition to our findings indicates that moderate exercise, such as walking, done for 2.5 hours per week may be enough to reduce mortality and to confer benefits of reducing cardiovascular risk factors. Although Gay and colleagues found similar results regarding physical exercise and AL, their minimum amount of exercise was substantially higher (>=1500 MET-minutes per week) and their sample was limited to Mexican Americans.[22] Upchurch et al reported an inverse relationship between AL and leisure time activity among White, Black, and Mexican American Women.[24] They specifically found that participants who reported moderate (600-1500 MET-minutes per week) and high (>1500 MET-minutes per week) leisure time physical activity had significantly lower allostatic load than those who were inactive (0 MET-minutes per week). These results are in line with what we found however our results imply that a high activity level isn't necessarily required to obtain the health benefits conferred from physical activity.

Those who reported being current alcohol users were also less likely to be in the metabolic plus blood pressure class compared to the low class. Our findings add to the mixed literature regarding alcohol use and metabolic risk factors and alcohol use and blood pressure. Multiple meta-analyses have shown that low-to-moderate alcohol use lowers the risk of metabolic syndrome compared to abstainers and that blood pressure is either positively or neutrally affected by low-to-moderate amounts of alcohol[20, 39, 40] while at least one study has shown higher risk of metabolic syndrome in current drinkers compared to abstainers.[41] Much of the literature regarding alcohol use and health utilizes international samples (e.g. Japanese, Chinese, and Italian). In our study more than half of the sample reported being current alcohol drinkers but of those who were current drinkers, nearly 60% reported have <=2 drinks a week meaning that the majority of the sample that endorsed drinking alcohol were low-to-moderate alcohol users. Due to such a large percentage of low-to-moderate drinkers, it is not surprising that alcohol use appeared to confer some benefit in our sample.

Our study had certain limitations. We did not have markers of inflammation in our AL construction which have been found to be important in recent literature. All of health behavior data was self-reported so although we had detailed questionnaires regarding physical activity and diet they were dependent upon the respondent's accuracy in reporting. We also didn't have specifics as to the type and amount of alcohol that current users drank which might provide a further explanation for the findings regarding alcohol use (e.g. if most current alcohol users have a glass of red wine each night that may be the reason that alcohol appears protective).

The strengths of our study include a large multi-ethic sample with biological data as well as a statistical approach that allowed for discovery of qualitative patterns in AL. Our sample was also diverse in age which allowed us to study physical activity in older adults who are typically less active.

In a 2008 commentary by Loucks et al[2] the authors list two of the main challenges of employing an allostatic load framework as – how best to measure AL; and understanding if AL is affected primarily by psychological stress or if there are other factors that are as or more important such as sedentary lifestyle, smoking, or diet. We addressed the latter in our first research question and former in the second research question. Our findings may have practical importance for middle-aged and older adults. For those who have metabolic and blood pressure indicators, moderate exercise may be an inexpensive way to help reduce the risk of cardiovascular factors regardless of age, race, or sex. Our study may also have implications for future research regarding AL. The qualitative differences in AL among our sample reveal the possibility that two people with a similar quantitative value of AL may not have the same risks or confer the same benefits from certain health behaviors. These findings could help to increase our understanding of how patterns of indicators of AL can differ from person to person and result in different outcomes.

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CHAPTER 5. THE INTERRELATIONSHIPS BETWEEN COGNITIVE FUNCTIONING, RACE, DISCRIMINATION, AND ALLOSTATIC LOAD: A PATH ANALYSIS

5.1 ABSTRACT

Many factors, including race, have been linked to cognitive function in middle and older aged individuals. The reasons for the associations between race and cognitive function are not completely understood. Although some causes have been discovered, there is still a large amount of variance in cognitive functioning that is unaccounted for. We utilized path analysis to explore the relationships between cognitive function, race, perceived discrimination, allostatic load, and health behaviors (smoking, diet, physical activity, alcohol use). We found that race and cognitive function were significantly associated as were discrimination and cognitive function, and allostatic load and cognitive function. Discrimination was highest among Blacks compared to Whites, Chinese, and Hispanics, however discrimination was not found to be associated with allostatic load as hypothesized. Possible explanations for the findings and implications are discussed.

5.2. INTRODUCTION

Cognitive functioning varies individually due to a host of factors including age, childhood factors such as socioeconomic status in childhood and maltreatment,[1, 2] obesity,[3-5] and race. Even in persons who do not suffer from cognitive impairment, cognitive function has been found to differ across racial groups.[6-10] In older populations (age 70+) scores on cognitive tests of verbal recall, number series, and global cognition were significantly lower for Blacks and Hispanics compared to Whites, with Blacks having the lowest scores overall.[7, 8] In those at risk for dementia, findings were similar with less educated Blacks having a higher risk of dementia than Whites of all education levels and educated blacks having a similar risk of dementia as uneducated blacks.[9] Although education quality may play a role in these findings,[11] social factors such as socioeconomic status and lack of education account for only some of the variation in cognitive scores between Blacks and Whites. Over the past decade, biological vulnerability or allostatic load has been studied as a factor contributing to cognitive function in both older[12] and middle-aged[13, 14] populations. Psychosocial factors such as perceived discrimination have also been studied[15, 16].

Although race, discrimination, and allostatic load have previously been studied as predictors of cognitive function, most models do not include all of these factors. Race and discrimination are often studied together as racial discrimination is one of the more pervasive and common forms of discrimination. As one would expect, even in a so-called "post-racial" society, racial discrimination tends to disproportionately affect Blacks compared to Whites.[17-22] Although Blacks tend to shoulder a larger burden of discrimination, their cognitive functioning appears to be most affected when discrimination is ambiguous as opposed to blatant when their cognitive function appears to increase,[16] whereas the opposite effect is seen in Whites.[15] Due to the limited number of studies on the topic it is unknown if this is a consistent finding. The current study aims to add to that body of research.

Increased allostatic load has been associated with decreased episodic memory and executive function in middle-aged to older adults[14, 23] as well as with decreases in processing speed, knowledge, and general cognitive ability.[23] Even in highly functioning older adults, allostatic load is associated with decreases in memory, spatial ability, and abstract reasoning.[12] Allostatic load has also been associated with race, with American-born Blacks demonstrating a higher burden of allostatic load than both Whites, foreign-born Blacks, Mexicans, and Mexican-Americans [24-27]. These findings are consistent with the "weathering" hypothesis of black individuals biologically aging earlier than their White individuals. This finding is evident across socioeeconomic groups and age groups. Though research is limited, and mostly conducted in adolescent populations, higher allostatic load has also been a demonstrated outcome of perceived discrimination[28] and not always racial discrimination.[29]

The independent associations between allostatic load and cognitive function, race and cognitive function, discrimination and cognitive function, allostatic load and race, discrimination and race, and discrimination and allostatic load beg the question of if these factors are interrelated. Of additional interest is the association between these variables and health behaviors such as diet, exercise, smoking, and alcohol use which have been shown to be associated with race,[30-33] discrimination,[19, 34] and allostatic load.[35-38] The aims of this study are to test the idea that discrimination and race may be associated with cognitive function through allostatic load and to add to current literature regarding the associations between race, discrimination, allostatic load, and cognitive function.

Although race is a key factor in our analysis we acknowledge that the use and measurement of race as a variable in research has been fraught with problems. Since anthropologists have pointed out that race is not a biological concept[39] but is rather a social classification, researchers must consider the factors indexed by race, and how measured and unmeasured factors associated with race influence covariates and outcomes. When considering race as a research variable, it is advisable to realize that "controlling for" race in a model is not an adequate treatment of such a complex variable.[40] Race is undoubtedly intertwined with socioeconomic status, education, group identification, and other social factors that cannot be captured with a "0" or a "1" in a statistical model. Researchers often do not have the option of measuring race in a more comprehensive way, but it is critical to complete analyses with the caveat that the "race" variable is a marker or proxy for many factors that must be incorporated into interpretation.

We hypothesize that AL will partially mediate the relationship between race and cognition, as well as between discrimination and cognition. We also hypothesize that health behaviors such as diet, alcohol use, physical activity, and smoking play a role in the relationship between race and discrimination on cognitive function through their effects on AL. Our goal is to test a model of how these variables may influence the observed differences in cognitive function by race (figure 1).

5.3. METHOD

5.3.1. PARTICIPANTS

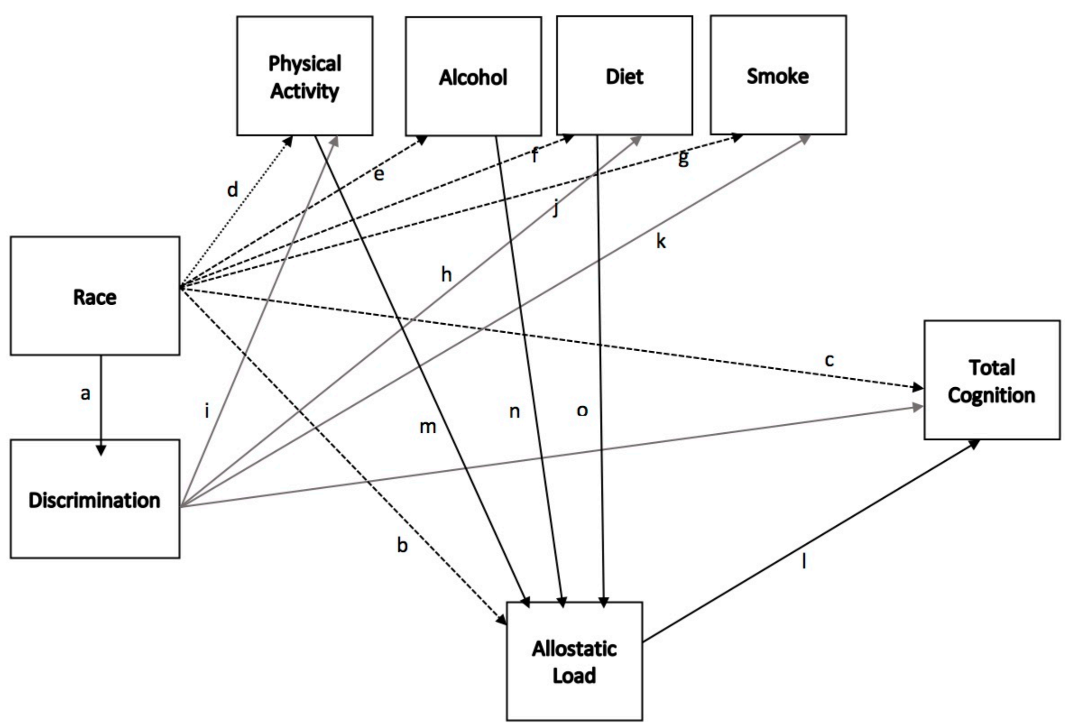
The sample was derived from the Multiethnic Study of Atherosclerosis (MESA). MESA consisted of 6,814 healthy male and female volunteers who reported their race/ethnicity as White, African American, Hispanic, or Asian. The volunteers were recruited from six study centers in various states throughout the US (NC, NY, MD, MN, IL, and CA). There were five examinations total between 2000 and 2012. Data used for this analysis comes from those participants who had complete allostatic load and cognitive data.

5.3.2. MEASURES

Cognitive Function. Cognitive function was examined with three standardized, well-validated tests at exam five. Global cognitive functioning was assessed with the Cognitive Abilities Screening Test (CASI).[41] Speed of processing was assessed using the Digit Symbol Coding Test (DSCT), a subtest of the Wechsler Adult Intelligence Scale-III (WAIS-III).[42] Working memory was assessed with another subtest of the WAIS-III, the Digit Span Test (Forward and Backward) (DST). For this analysis cognitive test scores were converted to z-scores based on sample norms. "Total Cognition" refers to a score derived from summing the z-scores from each cognitive test.

Allostatic Load. Allostatic load was measured with a cardiometabolic index that was created for use in MESA, as opposed to AL variables that include measures of other biological systems such as inflammatory response markers and stress hormones, and has been used previously.[43] Metabolic indicators included in the index were waist-to-hip ratio, triglycerides, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and glucose (only those who fasted $\geq$ 10 hours were used for triglycerides, LDL cholesterol, and glucose). Glucose was log-transformed to due skewness. Cardiovascular indicators included in the index were systolic blood pressure, resting heart rate, and pulse pressure. All values were standardized to clinical cutpoints and population-based standard deviations based on visit one so that the value for any individual system represents the number of standard deviations relative to accepted clinical thresholds. The clinical cutpoints were: 0.90 waist-to-hip ratio for men and 0.85 for women, 200 mg/L for triglycerides, 160 mg/dL for LDL cholesterol, 40 mg/dL

Figure 5.1. Path model of the hypothesized relationship between race, discrimination, allostatic load, health behaviors, and cognitive function in the Multiethnic Study of Atherosclerosis, 2000-2012.



high-density lipoprotein cholesterol, 126 mg/dL of glucose, 140 mm Hg for systolic blood pressure, 60 mmHg for pulse pressure, and 90 beat/min for heart rate.[43] The scores for those on medications such as glucose and beta blockers were computed based on their values at the time of evaluation regardless of medication use. The standardized scores were then summed to create a cardiometabolic index. For those participants missing more than four components (out of 8), the score was set to missing. For those missing less than four components the missing value was imputed based on the average value of all other visits as long as the averages were based on at least 2 visits. If averages were based on less than 2 visits, then the score was set to missing. Although scores were available for all five exams we chose to use the score from exam five as it was the closest in time to the cognitive testing scores.

Discrimination. Perceived lifetime discrimination was measured using the Major Experiences of Discrimination Scale[44] ($\alpha = 0.65$) and daily hassles were measured using the Everyday Discrimination scale[45] ($\alpha = 0.87$). The Major Experiences of Discrimination Scale asks questions such as "Was there ever a time that you were unfairly denied a promotion, unfairly not hired for a job, treated unfairly by the police" etc. Multiple reasons for discrimination are provided for the participant to choose. This score was represented as a continuous score of 0-6 regardless of reason for discrimination. The Everyday Discrimination Scale gives nine scenarios of everyday harassment such as "people act as if they are better than you", "people act as if you are dishonest", and "receive poorer service than others". The response options range from "almost every day" to "never". This score was also represented as a continuous score with a range of 9 ("never" for all scenarios) to 54 ("almost every day" for all scenarios).

Ethno-racial Category. Participants self-identified as either "Spanish/Hispanic/Latino", "African-American or Black", "Chinese", or "Caucasian or White" at screening prior to exam 1.

Health Behaviors. Health behaviors were defined as smoking, drinking alcohol, physical activity, and diet and were reported at exam 1. Smoking was defined as number of pack-years.

Alcohol use was defined as number of drinks per week for current drinkers where non-drinkers were given a “zero” value. Physical activity was defined as number of metabolic equivalent task (METs) minutes per week of intentional exercise (e.g. walking, dancing, sport, conditioning). MET-minutes are defined by multiplying the number of METs expended in an activity by the number of minutes performed each week. The diet variable was empirically derived from data collected through the Food Frequency Questionnaire (FFQ). Previous MESA authors who conducted the diet sub-study derived food groups from the FFQ.[46] Principle component analysis was conducted on the food groups to determine the number of factors that best represented the eating habits in this sample. Similar to the factor analyses done by other authors, four factors were derived. The factor representing poor eating habits (sweets, soda, fried foods) was the diet variable employed in this analysis, with higher scores indicating poorer diet.

Covariates. Socioeconomic (SES) disadvantage was constructed as a total score that encompassed income/poverty ratio, education level, insurance, and whether the participant owns or rents their home. The scores ranged from 0 (income/poverty ratio $\geq$ 600%, bachelor’s degree or higher, private insurance, and own home free and clear) to 8 (income/poverty ratio $<$ 300%, high school education or less, no insurance, and rent home) with higher scores indicating larger disadvantage. Age was participant’s age at exam 5 and sex was self-reported as male or female. Stress (non-discrimination related) was obtained using the Chronic Burden Scale[47] ($\alpha = 0.84$), a five questions scale that asks about common stressors such as chronic illness in oneself or a loved one and how stressful the person finds it (e.g. not very stressful, moderately stressful, very stressful). The score ranged from 0 (no chronic stressors) to 15 (all five chronic stressors considered very stressful). Depressive symptoms were measured using the Center for Epidemiologic Studies Depression Scale (CES-D)[48, 49] ($\alpha = 0.76$). The scale consists of 20 questions with a score of 0-3 for each item (total score range 0-60). Site indicated at which site the participant completed the exams.

5.3.3. STATISTICAL ANALYSIS

Path analysis is a special form of structural equation modeling that uses only manifest (measured) variables. We chose path analysis due to its flexibility in model specification and for the ability to specify variables as both dependent and independent simultaneously which is not available in traditional linear regression. In addition, path analysis has the capability to estimate all of the hypothesized relationships simultaneously which is beneficial with such complex subject matter. We hypothesized the following associations based on literature: race and discrimination, physical activity, alcohol, diet, smoke, AL, cognition; discrimination and physical activity, alcohol, diet, smoke, AL, cognition; physical activity and AL; alcohol and AL; Diet and AL; smoke and AL; and AL and cognition. We tested our proposed model for identifiability using the T-Rule which tests the number of parameters against the number of variances to be estimated, and the recursive rule which ensures that there is no reciprocal causation. The model was determined to be identified. We fitted models where we included race as a grouping variable rather than as a path in order to determine the proportion of variance in cognitive function accounted for by the predictors in the model within each race. We began the main analysis by fitting a model with all of the hypothesized associations and added the control variables (age, socioeconomic disadvantage, sex, non-discrimination stress, depressive symptoms, and site) that were hypothesized to be associated with the outcomes based on literature. All main variables (as opposed to control variables) were continuous except race which was represented by a series of dummy variables that compared Black, Chinese, and Hispanic to the reference group of White. We ran separate models for each type of discrimination (Daily Hassles and Lifetime Discrimination) and for each cognitive outcome (Total Cognition, CASI, Digit Symbol Replacement, and Digit Span) resulting in two models per cognitive outcome for a total of 8 models. The initial models had excellent fit statistics (RMSEA = 0.000, CFI = 1.00, TLI = 1.01, SRMR = 0.001). We did not use the Chi-Square test for model fit because it is known to be significant regardless of fit when sample size is large.[50] After running the initial models, we trimmed non-significant paths that were consistent throughout all models and that did not include control variables. Control variable paths were left intact so that all models were adjusted in the same way. We then reran the models without the non-significant paths. Fit statistics remained excellent for all models (RMSEA = 0.000, CFI = 1.00, TLI = 1.01, SRMR = 0.002). Fit statistics remained the same for the models where race was the grouping variable as well, with the exception of the SRMR increasing to 0.006. Sample statistics were computed in Stata 13[49] and path analysis was conducted in MPlus v.7.[51]

5.4. RESULTS

5.4.1. SAMPLE

The total available sample size was 4591 of which 41% were White, 26% were Black, 21% were Hispanic, and 12% were Chinese. Fifty-three percent were female and percentage at each site ranged from 14% from JHU to 19% from Northwestern University. Mean age of participants at baseline was 60 years old (range: 44-84). Mean age at exam 5 was 70 years old (range: 53-94). Analytic sample sizes ranged from 3935 for Total Cognition to 4423 for Digit Span Total, though the relative percentage of participants by race was consistently similar to the full sample. AL data was available in 99% of participants at exam 5. Discrimination data was available in 99% of the sample and health behavior data availability ranged from 96% for diet data to 99% for alcohol and smoking data. Descriptive data for the main variables of the path analysis can be found in Table 1.

Table 5.1. Descriptive data for main study variables by total sample and by race in the Multiethnic Study of Atherosclerosis, 2000-2005

	Total Sample (n = 4591)	White (n = 1868)	Chinese (n=528)	Black (n = 1211	Hispanic (n = 984)
CASI*	87.7+8.6 (23.2 – 100.0)	91.4+6.6 (41.9 – 100.0)	85.9+8.6 (23.2 – 100.0)	86.4 +8.1 (45.6 – 100.0)	83.4+9.6 (34.6 – 100.0)
Digit Span Total	15.2+4.5 (0.0 – 30.0)	16.5+4.1 (0.0 – 29.0)	18.1+4.7 (0.0 – 30.0	14.6+3.9 (0.0 – 28.0)	12.0+3.9 (0.0 – 28.0)
Digit Symbol Substitution	50.2+18.6 (0.0 – 120.0)	56.6+16.3 (0.0 – 113.0)	56.2+18.6 (11.0 – 102.0)	45.2+16.7 (0.0 – 120.0)	41.4+19.2 (0.0 – 103.0)
Lifetime Discrimination	0.8+1.1 (0.0 – 6.0)	0.6+0.9 (0.0 – 5.0)	0.4+0.7 (0.0 – 4.0)	1.3+1.3 (0.0 – 6.0)	0.7+1.0 (0.0 – 6.0)
Daily Hassles	14.9+6.0 (9.0 – 54.0)	14.6+5.0 (9.0 – 38.0)	13.1+5.0 (9.0 – 39.0)	17.0+6.9 (9.0 – 54.0)	13.8+6.2 (9.0 – 54.0)
Allostatic Load	-8.1+3.5 (-19.8 – 8.0)	-8.7+3.4 (-19.8 – 3.3)	-8.1+3.3 (-17.3 – 4.1)	-8.1+3.5 (-18.0 – 6.35)	-7.1+3.5 (-18.2 – 8.0)
Physical Activity (MET-MIN/wk)	1437.0+1712.0 (0.0 – 9945.0)	1527.1+16.27.0 (0.0 – 9900.0)	1075.5+1319.1 (0.0 – 8400.0)	1545.0+1906.1 (0.0 -9922.5)	1328.3+1777.1 (0.0 – 9945.0)
Alcohol (Drinks per week)	2.5+5.4 (0.0 – 64.0)	3.9+6.4 (0.0 – 50.0)	0.6+2.6 (0.0 – 30.0)	1.6+4.2 (0.0 – 64.0)	1.8+5.0 (0.0 – 50.0)
Poor Diet	2.7+1.9 (-0.7 – 20.5)	3.1+1.8 (-0.4 – 14.1)	1.3+1.1 (-0.6 – 7.9)	2.9+2.2 (-0.7 – 20.5)	2.6+1.9 (-0.5 – 16.1)
Smoking (pack years)	10.4+19.7 (0.0 – 265.0)	13.6+23.3 (0.0 – 265.0)	4.2+13.1 (0.0 – 162.0)	11.2+18.1 (0.0 – 193.5)	6.8+15.4 (0.0 – 126.0)

Mean+SD (range)
*CASI = Cognitive Abilities Screening Instrument

5.4.2. PATH ANALYSIS

We estimated eight models in total: CASI with daily hassles and lifetime discrimination; Digit Span with daily hassles and lifetime discrimination, Digit Symbol with daily hassles and lifetime discrimination, and Total Cognition with daily hassles and lifetime discrimination. All four outcomes produced similar path coefficients so we report on the total cognition models. Any coefficients that differed significantly from one model to another will be noted. In the final model of total cognition 46% of the variation in total cognition was accounted for by the predictors in the model including the control variables (socioeconomic disadvantage, age, stress, depressive symptoms, sex, and site). About 7% of the variance of AL was accounted for by the predictors in the model. When race-specific models were run 31% of the variance in total cognition was accounted for among Whites, 27% among Chinese, 34% among Blacks, and 37% among Hispanics. The variance of AL accounted for by the predictors in race-specific models was highest among Chinese (9%) and lowest among Black and Hispanic (4%).

5.4.3. DIRECT EFFECTS

Table 2 shows the model results and standard errors as well as the standardized direct effects for the final path model. The lettered indicators in table 2 correspond with the lettered paths in figure 1. Cognitive function was found to vary by race. Both Blacks (model results (b) = -1.16, SE = 0.07, standardized (β) = -0.52) and Hispanics (b = -1.70, SE = 0.08, β = -0.73) demonstrated lower total cognition than Whites while Chinese demonstrated higher total cognition than Whites (b = 0.22, SE = 0.11, β = 0.10). With White race as the reference category, Blacks and Hispanics reported significantly higher amounts of lifetime discrimination while only Blacks reported significantly higher amounts of daily hassles compared to Whites (b = 0.20, SE = 0.02, β = 0.47). Discrimination was found to be weakly, but significantly associated with cognitive function, it was not however associated with allostatic load in any of the models so the path from discrimination to allostatic load was omitted from the final model. Allostatic load was found to differ significantly by race with Chinese (b = 0.43, SE = 0.21, β = 0.12), Blacks (b = 0.47, SE = 0.15, β = 0.12), and Hispanics (b = 1.04, SE = 0.17, β = 0.29) all having significantly higher allostatic load compared to Whites. Race was significantly associated with cognitive function among all groups. Blacks and Hispanics had significantly lower cognitive function compared to Whites (b = -1.16, SE = 0.07, β = -0.52; b = -1.70, SE = 0.08, β = -0.73, respectively) in all models while Chinese had significantly higher cognitive function in all models (b = 0.22, SE = 0.11, β = 0.10) where they were also significantly lower than whites (b = -0.42, SE = 0.05, β = -0.43).

Of the health behaviors, only physical activity and diet were consistently and significantly associated with allostatic load. Physical activity had a small negative association with allostatic load while diet had a small positive association with allostatic load. Alcohol was only associated with AL when the Digit Symbol Substitution test was the outcome and that relationship was weak as well. Smoking was not at all associated with allostatic load and thus that path was omitted in the final model. Physical activity, diet, and smoking were all consistently positively associated with both forms of discrimination indicating that an increase in lifetime discrimination was associated with significantly greater amounts of physical activity (b = 0.05, SE = 0.02, β = 0.05), poorer diet (b = 0.11, SE = 0.03, β = 0.06), and more pack-years of smoking (b = 0.87, SE = 0.31, β = 0.05). Similarly, daily hassles were associated with significantly greater amounts of physical activity, poorer diet, and more pack-years of smoking. Alcohol use was not associated with any form discrimination in any model so the path was removed for the final model.

Overall, Chinese participants had significantly less MET-Mins/wk than Whites (b = -0.13, SE = 0.06, β = -0.13) whereas Blacks and Hispanics had more MET-Mins/wk than Whites, but not significantly so. For other health behaviors Whites had significantly more drinks per week than all other groups, significantly poorer diets than all other groups, and significantly more pack years than all other groups.

5.4.4. INDIRECT EFFECTS

Overall, most of the indirect effects in the models were very small though significant due to the large sample size (Table 3). The indirect effects of interest were those from race to cognition through discrimination and allostatic load. The largest indirect effects from race to cognition were between black and white through discrimination and this effect was evident for both lifetime discrimination (0.70*0.05 = 0.03, p <0.001) and daily hassles (0.47*0.06 = 0.03, p<0.001) (Table 3a). No significant direct or indirect effects were found between discrimination and AL because the path was eliminated due to non-significance. A very small indirect effect was found between race and cognition through allostatic load, but only for Blacks (0.12*-0.08 = 0.01, p<0.01) and Hispanics (0.29*-0.08 = -0.02, p<0.001).

5.5. DISCUSSION

We found that in a multi-ethnic sample race, discrimination and allostatic load was associated with cognitive function. We hypothesized that AL could be a mechanism for the relationship between race and cognitive function as well as between discrimination and cognitive function. We found that there are racial differences in cognitive functioning and that allostatic load is one possible mechanism for this disparity. Although discrimination was associated with cognitive function in our sample, it was not associated with allostatic load and thus did not provide support for allostatic load as a mechanism of association between discrimination and cognitive function. These findings indicate that cognitive test scores continue to be disparate by race and that there appear to be causes in addition to the factors that we tested. These findings also add to the literature regarding the deleterious association of AL with cognitive functioning.

Discrimination was positively associated with cognitive function indicating that an increase in either lifetime discrimination or daily hassles was associated with increased scores on cognitive tests. This was evident for all races though it was slightly stronger for all races except Whites. Compared to

Table 5.2. Maximum Likelihood Estimates for Final Model of Race, Discrimination, Health Behaviors, and Total Cognition (n = 3935) in the Multiethnic Study of Atherosclerosis, 2000-2005

Variables	Lifetime Disc			Allostatic Load			Cognitive Function			Physical Activity			Alcohol			Diet			Smoke		
	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β
Race																					
Chinese v. White	-0.15*	0.60	-0.14[a]	0.43*	0.21	0.12[b]	0.22*	0.11	0.10[c]	-0.13*	0.06	-0.13[d]	-3.87*	0.30	-0.73[e]	-1.58*	0.11	-0.83[f]	-9.86*	1.15	-0.51[g]
Black v. White	0.70*	0.04	0.70	0.47*	0.15	0.14	-1.16*	0.07	-0.52	0.06	0.04	0.06	-1.86*	0.22	-0.35	-0.35*	0.08	-0.18	-3.29*	0.84	-0.17
Hispanic V. White	0.20*	0.05	0.20	1.04*	0.17	0.29	-1.70*	0.00	-0.73	0.07	0.05	0.07	-1.99*	0.24	-0.38	-0.65*	0.09	-0.34	-8.80*	0.92	-0.45
Lifetime Disc	-	-	-	-	-	-	0.10*	0.03	0.05[h]	0.05*	0.02	0.05[i]	-	-	-	0.11*	0.03	0.06[j]	0.87*	0.31	0.05[k]
Allostatic Load	-	-	-	-	-	-	-0.06*	0.01	-0.08[l]	-	-	-	-	-	-	-	-	-	-	-	-
Physical Activity	-	-	-	-0.17*	0.05	-0.04[m]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Alcohol	-	-	-	-0.02	0.01	-0.03[n]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diet	-	-	-	0.08*	0.03	0.05[o]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Smoking	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-

Variables	Daily Hassles			Allostatic Load			Cognitive Function			Physical Activity			Alcohol			Diet			Smoke		
	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β	b	SE	β
Daily Hassles	-	-	-	-	-	-	0.14*	0.03	0.06	0.04*	0.02	0.04	-	-	-	0.19*	0.03	0.10	0.81*	0.34	0.04
Chinese v. White	-0.05	0.05	-0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Black v. White	0.47*	0.04	0.47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hispanic v. White	-0.04	0.04	-0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

*$p \leq 0.05$
[a]Superscript letters refer to paths in figure 1
β = Standardized Coefficient

Table 5.3. Standardized direct, indirect, and total effects from race to total cognition in the Multiethnic Study of Atherosclerosis, 2000-2005

Race	Direct	Indirect	Total
Chinese v. White	0.101*	-0.015*	0.086
Black v. White	-0.522*	0.022*	-0.501*
Hispanic v. White	-0.732	-0.014*	-0.746*

*P ≤ 0.05

Table 5.3a. Standardized specific indirect effects from race to total cognition in the Multiethnic Study of Atherosclerosis, 2000-2005

Race	Race →AL→Cog	Race→Alc→ AL→Cog	Race→Diet→ AL→Cog	Race→lifedisc →Cog	Race→dhassle →Cog
Chinese v. White	-0.010	-0.002	0.003*	-0.006*	-0.003
Black v. White	-0.009*	-0.001	0.001*	0.031*	0.028*
Hispanic v. White	-0.023*	-0.001	0.001*	0.009*	-0.003

*P ≤ 0.05

Whites, Blacks and Hispanics showed decreased cognitive test scores and increased perceived discrimination. Since discrimination was positively associated with total cognition we found that it actually attenuated the negative difference between Blacks and Whites and between Hispanics and Whites in cognition decreasing the disparity between the two groups slightly. We hypothesized that discrimination would be associated with cognitive function but not in a particular direction It isn't completely unexpected, however, that increased discrimination was associated with increased cognitive function. Sutin and colleagues[16] found that increased racial discrimination was associated with increased cognitive health among African Americans and the opposite effect was found among Whites. Although we didn't find a decrease in cognitive function in Whites we did find similar results in African Americans. One explanation for this might be in the findings of Salvatore and Shelton[15] where Blacks only showed increased reaction time in a Stroop task when discrimination was ambiguous and they had to decide if it was actually discrimination whereas Whites only showed increased reaction time when discrimination was blatant. The authors hypothesize that it takes more cognitive power to decide if an event is discriminatory and since discrimination is more common among blacks they're more likely to have to decide, whereas Whites may assume that there is no discrimination if it's not obvious. Since both measures of discrimination used in this study ask participants about times when they were discriminated against the participants, by definition, understood these situations to be blatant discrimination, at least in retrospect. It is possible that we would have seen different results if the measure asked about more ambiguous situations.

Our finding that an increase in allostatic load was associated with a decrease in cognitive test scores, adds to previous literature showing associations between allostatic load and cognitive functioning.[14, 23] Allostatic load was also consistently higher among Blacks and Hispanics than Whites and there was a significant though very small indirect effect from race to cognitive function through allostatic load. The lack of a significant relationship between allostatic load and discrimination was unexpected based on limited previous research. Fuller-Rowell and colleagues[29] found that perceived discrimination due to social status accounted for 13% of the of the effect of poverty on allostatic load among adolescents. Similarly, a study by Brody and colleagues[28] conducted on adolescents with discrimination scores at three time points found that those with high discrimination, that was stable throughout adolescence, were more likely to have increased AL at age 20 than those who had low discrimination that steadily increased throughout adolescence. The authors did find that those in the "high and stable" group who had emotional support had AL levels similar to those in the "low" group. Since we didn't include coping mechanisms such as emotional support in this study there is the possibility that there is some form of coping attenuating the relationship of discrimination to AL. Although the association wasn't significant it was a consistently negative association meaning that increased discrimination was associated with a decrease in allostatic load. This again could be due to some form of coping.

We further hypothesized that race, discrimination and allostatic load would be associated with health behaviors. Research has shown that cigarette smoking and alcohol use have been used as coping mechanisms for those who perceive discrimination.[19, 34] We found similar results for smoking in that both types of discrimination were associated with more pack-years of smoking but we didn't find any association with alcohol use. We also found that increased physical activity and poorer diet were associated with both types of discrimination. Both the discrimination measures and the food questionnaire were conducted at the first exam so there is no way to know if these behaviors are a reaction to being discriminated against or those who participate in these behaviors are more likely to perceive discrimination. Among health behaviors, only diet and physical activity were associated with allostatic load so that increased physical activity was associated with decreased allostatic load score and poorer diet was associated with increased allostatic load score. These findings are not unexpected as exercise tends to have a positive association with the components of allostatic load and poor diet tends to have a negative association with the components of allostatic load. Previous research has shown that people who are poor and black are less likely to meet food guideline recommendations and are more likely to eat highly processed, salty, and sugary foods.[30, 31] We did find that higher socioeconomic disadvantage was associated with poorer diet but even with socioeconomic disadvantage controlled for, all minority races in the sample had better diet scores than Whites. Research has also shown that Blacks are less likely to exercise in their free time than Whites.[32, 33] Our study did not reveal a significant difference between Blacks and Whites or Hispanics and Whites in amount of exercise, but non-significant coefficients showed both Blacks and Hispanics to have slightly more exercise per week than Whites. Since one of the hypotheses for Blacks exercising less than Whites is neighborhood characteristics and we were unable to include neighborhood characteristics, such as built environment and feelings of unsafety, that may have been a factor in our findings.

Our study had certain limitations. We did not have discrimination data at more than one time-point so our study is cross-sectional making it impossible imply any causality. The number of participants who reported racial discrimination was small so we were unable to look at racial discrimination alone. Finally, we weren't able to include neighborhood data or socioeconomic data throughout the lifespan which could have had associations with most of the main variables.

There were also multiple strengths in our study. We had a large multiethnic sample which allowed us to compare variables between races. We also had discrimination, biological, and cognitive data in a multi-ethnic population which is often difficult to find. A large age range allowed us to include middle-aged adults in addition to older adults which may help to understand the disparity earlier in life when it could still be helped.

In conclusion, future research should examine discrimination, allostatic load, and cognitive function longitudinally to see if there are mechanisms that can't be seen cross-sectionally. Although smoking, alcohol use, and poor diet were less common among minorities than among Whites in this study, smoking, and poor diet were associated with perceived discrimination which in this study was more common among minorities. This may be a point of intervention for those who perceive discrimination. Future research should also include lifespan factors such as socioeconomic disadvantage in childhood and adolescence and education quality. Finally, the way in which people cope with discrimination may be a very important factor for future research because it may be associated with the increase in cognition that was seen in the sample. These findings contribute to the literature on allostatic load and cognitive function and reinforce the idea that discrimination is more common among minorities.

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CHAPTER 6. PERCEIVED DISCRIMINATION AND ALLOSTATIC LOAD: THE ROLE OF COPING STYLE AND SOCIAL SUPPORT

6.1 ABSTRACT

Perceived discrimination has been shown to be associated with mental and physical health, including allostatic load. Previous research has shown that coping style is associated with blood pressure and helplessness. Further, studies among adolescents have shown social support to be protective against allostatic load over time. The aim of this research is to explore the possible association of coping style and social support on the relationship between perceived discrimination and allostatic load. We used multivariable linear regression on a sample of 4123 participants from the Multi-ethnic Study of Atherosclerosis. The results showed that coping style as measured in this study did not moderate the relationship between perceived discrimination and allostatic load, though coping style was associated with allostatic load independent of level of perceived discrimination. Implications concerning coping and social support on perceived discrimination are discussed.

6.2. INTRODUCTION

Perceived discrimination has a demonstrated relationship to mental health.[1-5] More recently, physical health such as cardiovascular disease,[6, 7] blood pressure,[8] and obesity[9] have gained attention in discrimination research. Many of the studies that have related perceived discrimination to physical health focus on systolic and diastolic blood pressure as an outcome due in part to the demonstrated disparity in blood pressure between Blacks and Whites. In one of the earliest studies of discrimination and blood pressure Krieger et al[10] found that among executive/professional black men, those who had not experienced discrimination in any area of life had diastolic blood pressure six points lower than those who reported discrimination in one or two areas (e.g. school, work, medical care, justice system).

Allostatic load, as an indicator of multisystem dysregulation of which blood pressure is only one component, may be a better marker of the biological toll taken on the body by chronic stress. Allostatic load has been predicted by factors such as race,[11-13] age,[12-16] socioeconomic status,[13, 15, 17, 18] and symptoms of depression[19] to name a few. Allostatic load has also been linked to perceived discrimination, although mainly in adolescents. One study found that Black adolescents who reported high, stable levels of perceived discrimination were more likely to have a higher AL score at age 20 than adolescents who reported low but increasing levels of perceived discrimination.[20] Adolescents in the "high and stable" group showed near normal levels of AL at age 20 if they had protective emotional support. This indicates that, at least in adolescents, emotional support can help to buffer the effects of discrimination on AL. Fuller-Rowell and colleagues,[21] in another study on adolescents, noted that when perceived discrimination was added to a model where poverty predicted allostatic load, the strength of the effect of poverty on allostatic load decreased by 13%. One of the driving factors for the current study is to extend the research on discrimination and allostatic load to a middle-aged and older population.

As previously mentioned, social support has been shown to buffer the effects of perceived discrimination on allostatic load and it is a known coping method for stress.[20, 22, 23] Though less studied, coping methods employed when perceiving discrimination are negative self-focus (e.g. feeling defenseless and unable to do anything about it) and religiosity,[24, 25] avoidance,[22, 23, 26] withdrawal, forbearance,[25] and strong ethnic identity.[27] Most of these studies did not show how the participant's physical health was associated with the way they chose to cope. Mental health was however found to be better when more external coping methods (e.g. problem solving, doing something about it, talking to someone) were used as opposed to avoidance.[22] One study did evaluate avoidance techniques for coping with discrimination and found that among working class black women, those who dealt with discrimination by "Accepting it as a fact of life and keeping it to themselves" had systolic blood pressure that was four points higher than those who "Did something about it and talked to others about it".[10] Although these findings are compelling more research needs to be conducted. The gap in recent research leads to another motivation for the current research – to better understand the association between coping with discrimination and physical health.

We hypothesize that perceived chronic discrimination will be associated with baseline allostatic load and change in allostatic load over a 5-year period. Further we hypothesize that coping will modify this relationship (figure 1) and that internal coping (e.g. keeping it to oneself, accepting it as a fact of life) will be detrimental while external coping (e.g. doing something about it, talking to others about it) and social support will be beneficial.

6.3. METHOD

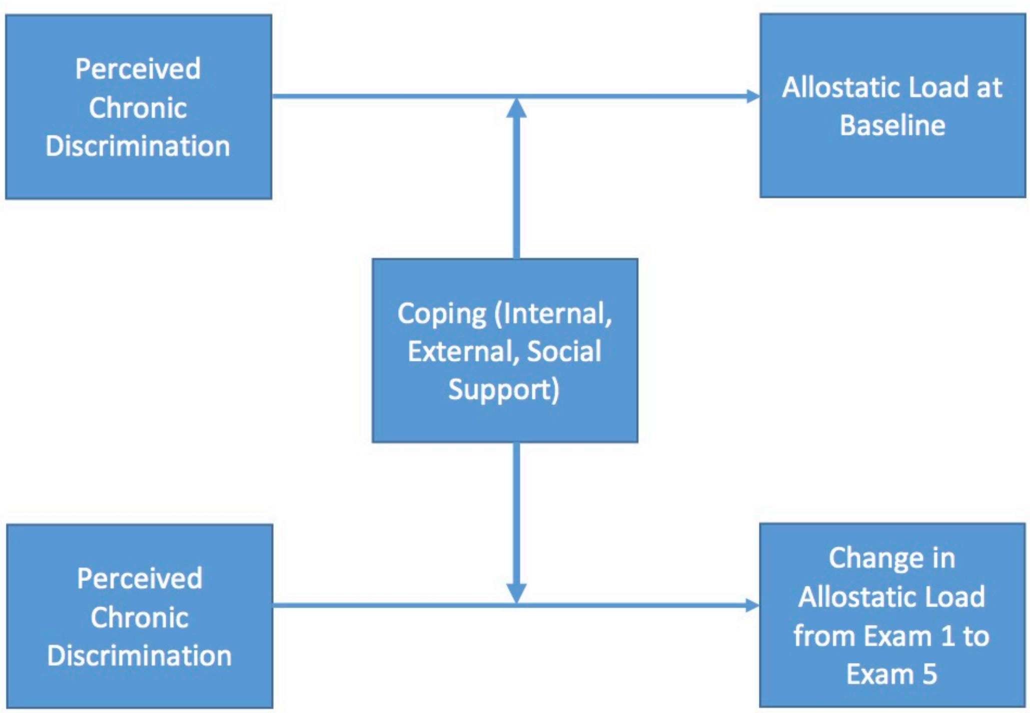
6.3.1. PARTICIPANTS

The sample for this study came from the Multiethnic Study of Atherosclerosis (MESA). MESA is a population based sample 6,814 healthy male and female volunteers. Participants came from six academic study sites throughout the US (NC, NY, MD, MN, IL, CA). Five exams were completed in total from 2000-2012 with yearly telephone follow-up. The subset of MESA used for this analysis consists of those who had complete data on all variables for a total sample size of 4128.

6.3.2 MEASURES

Allostatic Load. Allostatic load was measured with a cardiometabolic index created for use in MESA by MESA investigators.[28] Metabolic indicators included in the index were waist-to-hip ratio, triglycerides, low-density lipoprotein (LDL) cholesterol, high-density lipoprotein (HDL) cholesterol, and glucose (only those who fasted $\geq$ 10 hours were used for triglycerides, LDL cholesterol, and glucose). Glucose was log-transformed due to skewness. Cardiovascular indicators included in the index were systolic blood pressure, resting heart rate, and pulse pressure. All values were standardized to clinical cutpoints and population-based standard deviations based on visit one so that the value for any individual system represents the number of standard deviations relative to accepted clinical thresholds. The clinical cutpoints were: 0.90 waist-to-hip ratio for men and 0.85 for women, 200 mg/L for triglycerides, 160 mg/dL for LDL cholesterol, 40 mg/dL high-density lipoprotein cholesterol, 126 mg/dL of glucose, 140 mm Hg for systolic blood pressure, 60 mmHg for pulse pressure, and 90 beat/min for heart rate.[28] The scores for those on medications such as glucose and beta blockers were computed based on their values at the time of evaluation regardless of medication use. The standardized scores were

Figure 6.1. Hypothesized moderation of coping on the relationship between perceived chronic discrimination and allostatic load at baseline and between perceived chronic discrimination and change in allostatic load from exam 1 to exam 5 in the Multiethnic Study of Atherosclerosis, 2000-2012.



then summed to create a cardiometabolic index. For those participants missing more than four components (out of 8), the score was set to missing. For those missing less than four components the missing value was imputed based on the average value of all other visits as long as the averages were based on at least 2 visits. If averages were based on less than 2 visits, then the score was set to missing. We used allostatic load values from exam 1 for the main analysis and values from exams 1 and 5 for the secondary analysis to create an AL change score (AL exam 5 – AL exam 1). Exam 1 was conducted from 2000 to 2001 and exam 5 was conducted from 2011 to 2012.

Discrimination. Chronic discrimination was measured using the Everyday Discrimination Scale[29] ($\alpha = 0.87$). The Everyday Discrimination Scale describes nine scenarios of perceived everyday discrimination such as "people act as if they are better than you", people act as if you are dishonest", and "you receive poorer service than others". Respondents can choose one answer from the following choices: Almost every day, at least once a week, a few times a month, a few times a year, less than once a year, and never. Answer values range from 1-6 for 9 questions for a continuous score ranging from 9 – 54. We represented chronic discrimination in categorically as none (9), low (10 -27), and high (>27). These cutoffs were derived based on the response options with "never" being "none", "less than once a year", "a few times a year", and "a few times a month" corresponding to "low/some", and "at least once a week" and "almost every day" corresponding to "high". We chose to categorize chronic discrimination for 3 reasons: The first being the large number of people who reported never having experienced any discrimination; second because prior research has successfully grouped discrimination into none, some, and high in order to compare amounts of discrimination; and third because the principle component analysis and factor analysis indicate that the items in the Everyday Discrimination scale have high shared variance indicating a common underlying latent construct.

Coping. Three types of coping are utilized for this study. External coping, internal coping, and social support. The external and internal coping variables are based on answers to the following coping questions on the Everyday Hassles Questionnaire: “When treated unfairly what do you do about it? 1. Accept it as a fact of life; 2. Do something about it” and When treated unfairly do you tell others or keep it to yourself? 1. Talk to others about it; 2. Keep it to yourself.” Due to poor internal consistency of the composite variables including both questions ($\alpha = 0.54$) so we included each question individually as two different external and internal coping variables. Social support was measured using the Social Support Instrument (SSI), a validated questionnaire that was created based on questions from the Medical Outcomes Survey.[30] The survey contained 6 questions regarding the availability of people to talk to when the participant has a problem. The answers were based on a likert scale (1 – 5) for a total available score of 30. The internal consistency of the SSI is good ($\alpha = 0.89$) and a confirmatory factor analysis indicated that all questions are measuring the same underlying construct. Due to large number of participants indicating high social support (mean = 24.24, sd = 5.20) and the low number of participants indicating no social support (0.26%) we dichotomized social support so that those who answered “some of the time”, “a little of the time” and “none of the time” to questions about whether social support was available were called “low” social support and those who answered “all of the time” and “most of the time” were called “high” social support.

Covariates. Socioeconomic (SES) disadvantage was constructed as a total score that encompassed measures of education and wealth (income/poverty ratio, education level, insurance, and own/rent home). The scores ranged from 0 (income/poverty ratio $\geq$ 600%, bachelor’s degree or higher, private insurance, and own home free and clear) to 8 (income/poverty ratio < 300%, high school education or less, no insurance, and rent home) with higher scores indicating larger disadvantage. Sex was self reported as male or female. Race was categorized based on participant’s self-identification as either “Spanish/Hispanic/Latino”, “African-American or Black”, “Chinese”, or “Caucasian or White”. Age was represented as continuous variable based on age recorded at exam 1. Depressive symptoms Depressive symptoms were measured using the

Center for Epidemiologic Studies Depression Scale (CES-D)[31] (α = 0.76). The scale consists of 20 questions with a score of 0-3 for each item (total score range 0-60). Stress (non-discrimination related) was obtained using the Chronic Burden Scale[32] (α = 0.84), a five questions scale that asks about common stressors such as chronic illness in oneself or a loved one and how stressful the person finds it (e.g. not very stressful, moderately stressful, very stressful). The score ranged from 0 (no chronic stressors) to 15 (all five chronic stressors considered very stressful). Smoking was defined as number of pack-years. Alcohol use was defined as number of drinks per week for current drinkers where non-drinkers were given a "zero" value. Physical activity was defined as number of metabolic equivalent task (METs) minutes per week of intentional exercise (e.g. walking, dancing, sport, conditioning). MET-minutes are defined by multiplying the number of METs expended in an activity by the number of minutes performed each week. The diet variable was empirically derived from data collected through the Food Frequency Questionnaire (FFQ). Previous MESA authors who conducted the diet sub-study derived food groups from the FFQ.[33] Principle component analysis was conducted on the food groups to determine the number of factors that best represented the eating habits in this sample. Similar to the factor analyses done by other authors, four factors were derived. The factor representing poor eating habits (sweets, soda, fried foods) was the diet variable employed in this analysis, with higher scores indicating poorer diet. All covariates were measured at exam 1.

6.3.3. STATISTICAL ANALYSIS

Multivariable linear regression models were used to estimate the relationship between allostatic load, chronic discrimination, and coping strategies. We ran 2 baseline multivariable linear regression models regressing AL score at exam 1 on chronic discrimination and change in AL score from exam 1 to exam 5 on chronic discrimination, respectively. We ran 5 additional models for each outcome including each coping style (external1, external2, internal1, internal2, social support) as well as an interaction term of chronic discrimination*coping. This method allowed us to explore the possibility of coping style moderating the association between allostatic load and chronic discrimination. We tested the normality and linearity assumptions of linear regression by inspecting a quantile-normal plot and a scatterplot of residuals versus fitted values, respectively. All analysis were conducted using Stata 13.[34]

6.4. RESULTS

6.4.1. SAMPLE

Overall, the sample was about 60 years old (SD = 9.50) and female (53%). The majority of the sample reported high social support (92%) and were more likely to use an external coping style (64% and 83% for each externalizing question respectively). The majority of the sample reported some/low chronic discrimination (73%) followed by no chronic discrimination (23%). Table 1 describes the main study variables and covariates by amount of discrimination. There was a small number of participants who reported high chronic discrimination but they were younger, tended to be black, reported less social support, had a poorer diet, and had more pack years of smoking compared those with reporting no chronic discrimination and some/low chronic discrimination.

6.4.2. ALLOSTATIC LOAD AT EXAM 1

Baseline Model. Participants who reported some/low chronic discrimination had lower allostatic load at baseline compared to those who reported no chronic discrimination (-0.37, se = 0.14, 95% CI: -0.64 - -0.10). Similarly, participants who reported high chronic discrimination had allostatic load scores that were significantly lower than those who reported no chronic discrimination (-0.99, se = 0.32, 95% CI: -1.62 – -0.36).

External Coping. Participants who indicated that they "do something about it" when they feel they are being treated unfairly tended to show a reduction in allostatic load regardless of discrimination level (-0.45, se = 0.23, 95% CI = -0.91 – 0.00). The association between level of discrimination and allostatic load remained negative when external coping and interactions between external coping and discrimination level were added to the model, although the amount of decrease in allostatic load for some/low chronic discrimination (-0.67, se = 0.22, 95% CI: -1.09 - -0.25) and high discrimination (-1.49, se = 0.52, 95% CI = -2.49 - -0.49) compared to no discrimination, increased.

Table 6.1. Sample Demographics by Level of Chronic Discrimination in the Multi-ethnic Study of Atherosclerosis , 2000-2005

	No Discrimination N = 1057	Low Discrimination N = 3325	High Discrimination N = 173	p-value of chi2 or ANOVA
Age at Exam 1[1]	63.69 (9.56)	59.33 (9.24)	56.43 (8.69)	p < 0.001
Race[2]				p < 0.001
White	348 (33.92)	1470 (44.21)	35 (20.23)	
Chinese	183 (17.31)	334 (10.05)	10 (5.78)	
Black	157 (14.85)	953 (28.66)	85 (49.13)	
Hispanic	369 (34.91)	568 (17.08)	43 (24.86)	
Female	550 (52.03)	1788 (53.77)	84 (48.55)	p = 0.284
CES-D	5.52 (6.19)	7.48 (7.17)	13.43 (10.20)	p < 0.001
Chronic Burden Scale	1.68 (2.18)	2.72 (2.86)	4.65 (3.53)	p < 0.001
Education: >= High School	757 (71.62)	2999 (90.20)	153 (88.95)	p < 0.001
Coping[3]				
"Do something about it"	615 (58.52)	2210 (66.61)	111 (64.53)	p < 0.001
"Talk to others"	828 (78.93)	2814 (84.89)	144 (83.72)	p < 0.001
"Accept it as a fact of life"	436 (41.48)	1108 (33.39)	61 (35.47)	p < 0.001
"Keep it to yourself"	221 (20.91)	501 (15.07)	28 (16.18)	p < 0.001
Social Support[4]				p < 0.001
Low	52 (4.92)	280 (8.43)	35 (20.47)	
High	1004 (95.08)	3041 (91.57)	136 (79.53)	
Allostatic Load at Exam 1	-7.29 (3.80)	-8.25 (3.76)	-8.46 (3.74)	p < 0.001
Change in AL between Exam 1 and Exam 5	-0.45 (3.23)	-0.02 (3.05)	0.68 (3.17)	p < 0.001
Poor Diet	2.26 (1.74)	2.82 (1.93)	3.40 (2.37)	p < 0.001
Pack Years	9.30 (20.47)	10.60 (19.48)	13.05 (19.84)	p = 0.036
Drinks per Week	2.04 (4.94)	2.64 (5.54)	1.98 (5.05)	p = 0.003
MET-MIN/WK	1280.99 (1664.49)	1488.19 (1721.52)	1478.50 (1831.70)	p = 0.003

[1]Mean (SD) for continuous variables
[2]N (%) for categorical variables
[3]Four coping questions asked in Daily Hassles Questionnaire
[4]Social support measured with the Social Support Instrument

The interactions between discrimination and external coping showed a trend toward a positive difference in slope as discrimination increased however none of the interactions were significant. Among those who answered “talk to others about it” when asked if they tell others when they are treated unfairly, the associations showed a similar trend as the first external coping question but none of the associations were significant.

Internal Coping. Participants who answered “accept it as a fact of life” when asked what they do when treated unfairly showed an increase in allostatic load at exam 1, regardless of discrimination level (0.46, se = 0.23, 95% CI: 0.00 – 0.92). The model showed a trend toward internal coping being associated with higher allostatic load at both some/low and high chronic discrimination compared to no coping at all but the results were not significant (table 2). The interactions terms for the model that included those who answered that they “keep it to yourself” when treated unfairly, the trend was the same and was also non-significant.

Social Support. Overall, social support did not appear to be associated with chronic discrimination in predicting allostatic load score at exam 1 based on the non-significant interaction between discrimination and social support. The association between discrimination and allostatic load was attenuated slightly when social support and its interaction term were added to the model, though the associations remained significant.

6.4.3 CHANGE IN ALLOSTATIC LOAD FROM EXAM 1 TO EXAM 5

Baseline Model. Without regard to coping, participants who reported high amounts chronic discrimination showed a significantl increase in allostatic load from exam 1 to exam 5 compared to those who reported no discrimination (0.69, se = 0.28, 95% CI: 0.15 – 0.41). There was an increase in AL in those who reported some/low discrimination compared to those who reported no discrimination, but it was not significant.

Table 6.2. Linear regression models predicting allostatic load score at exam 1.

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)	Model 5 β (SE)	Model 6 β (SE)
Low Discrimination	-0.37 (0.14)*	-0.67 (0.22)*	-0.46 (0.30)	-0.16 (0.17)	-0.34 (0.15)*	-0.34 (0.14)*
High Discrimination	-0.99 (0.32)*	-1.49 (0.51)*	-1.23 (0.74)	-0.71 (0.40)	-0.93 (0.35)*	-0.83 (0.35)*
"Do something about it" when treated unfairly	---	-0.46 (0.23)*	---	---	---	---
External1 x Disc						
Low	---	0.50 (0.27)	---	---	---	---
High	---	0.78 (0.64)	---	---	---	---
"Talk to others about it" when treated unfairly	---	---	-0.18 (0.28)	---	---	---
External2 x Disc	---					
Low	---	---	0.12 (0.33)	---	---	---
High	---	---	0.31 (0.80)	---	---	---
"Accept it as a fact of life" when treated unfairly	---	---	---	0.46 (0.23)*	---	---
Internal1 x Disc						
Low	---	---	---	-0.50 (0.27)	---	---
High	---	---	---	-0.78 (0.64)	---	---
"Keep it to yourself" when treated unfairly	---	---	---	---	0.18 (0.28)	---
Internal2 x Disc						
Low	---	---	---	---	-0.11 (0.33)	---
High	---	---	---	---	-0.30 (0.80)	---
Low social support	---	---	---	---	---	0.71 (0.54)
Disc x Social Support						
low/low	---	---	---	---	---	-0.79 (0.58)
high/low	---	---	---	---	---	-0.93 (0.88)

*$p \leq 0.05$
Discrimination measured with Daily Hassles Questionnaire
Low/High discrimination compared to "none"
Social support measured with Social Support Instrument
All models controlled for socioeconomic disadvantage, gender, race, age, depressive symptoms, stress, diet, smoking, alcohol use, physical activity, and site.

External Coping. Neither form of external coping (doing something about it and talking to others about it) was associated with change in AL. Further, externalizing did not moderate the relationship between chronic discrimination and change in allostatic load (table 3).

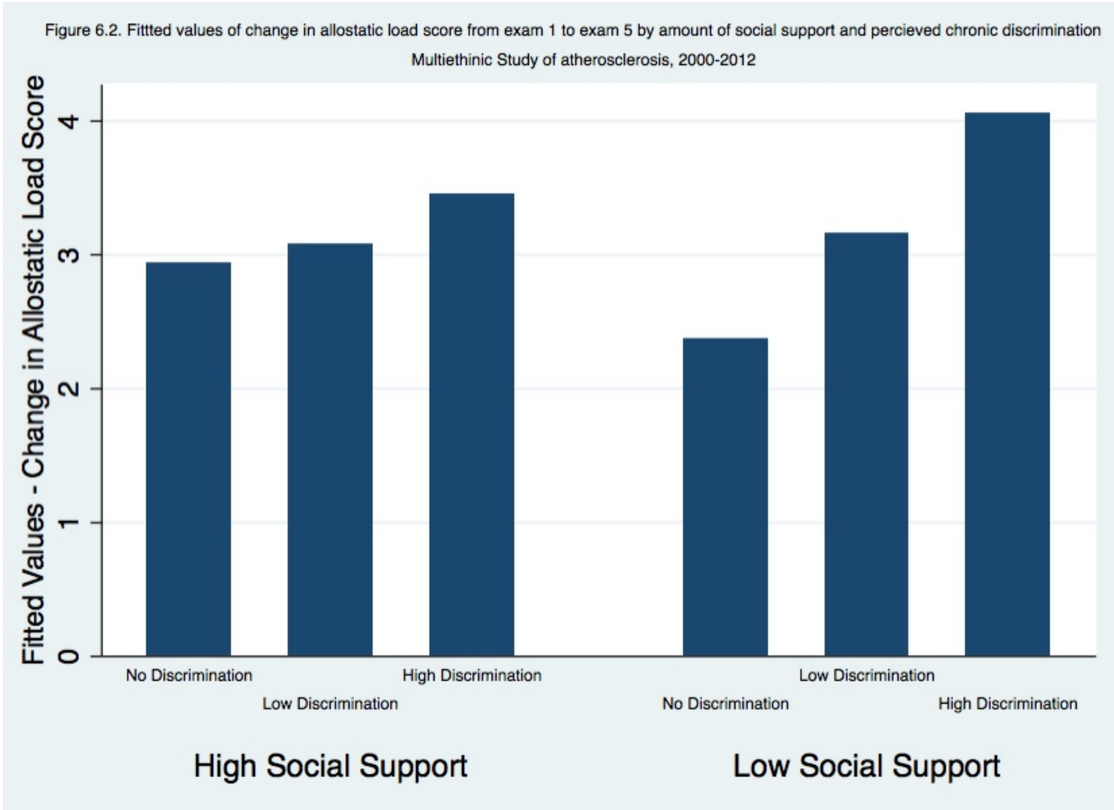
Internal Coping. Much like external coping, internal coping (accepting it as a fact of life and keeping it to yourself) did not show a significant association with change in allostatic load or with amount of chronic discrimination. In both internal models the increase in change in allostatic load remained significant between those with high chronic discrimination compared to those without discrimination and non-significant interaction did not change that association (table 3).

Social Support. The interactions between social support and discrimination were not significant indicating that social support did not moderate the relationship between discrimination and change in allostatic load. Figure 2 shows the change in allostatic load by discrimination and level of social support. The addition of social support and the interaction term to the model attenuated the association between discrimination and change in allostatic load so that the increase in allostatic load was no longer significant. We briefly considered partial mediation as a possibility however the lack of significance in the social support term and the interaction terms make mediation unlikely.

Table 6.3. Linear regression models predicting change in allostatic load score from exam 1 to exam 5.

	Model 1 β (SE)	Model 2 β (SE)	Model 3 β (SE)	Model 4 β (SE)	Model 5 β (SE)	Model 6 β (SE)
Low Discrimination	0.17 (0.12)	0.09 (0.18)	-0.07 (0.26)	0.22 (0.15)	0.24 (0.13)	0.14 (0.12)
High Discrimination	0.69 (0.28)*	0.87 (0.45)*	0.52 (0.63)	0.67 (0.34)*	0.74 (0.30)*	0.52 (0.31)
"Do something about it" when treated unfairly	---	-0.12 (0.20)	---	---	---	---
External1 x Disc						
Low	---	0.13 (0.23)	---	---	---	---
High	---	-0.19 (0.55)	---	---	---	---
"Talk to others about it" when treated unfairly	---	---	-0.39 (0.24)	---	---	---
External2 x Disc	---					
Low	---	---	0.30 (0.28)	---	---	---
High	---	---	0.21 (0.69)	---	---	---
"Accept it as a fact of life" when treated unfairly	---	---	---	0.12 (0.20)	---	---
Internal1 x Disc						
Low	---	---	---	-0.13 (0.23)	---	---
High	---	---	---	0.20 (0.55)	---	---
"Keep it to yourself" when treated unfairly	---	---	---	---	0.38 (0.24)	---
Internal2 x Disc						
Low	---	---	---	---	-0.31 (0.28)	---
High	---	---	---	---	-0.21 (0.69)	---
Low social support	---	---	---	---	---	-0.57 (0.46)
Disc x Social Support						
Low/Low	---	---	---	---	---	0.65 (0.50)
High/Low	---	---	---	---	---	1.18 (0.76)

*$p \leq 0.05$
Discrimination measured with Daily Hassles Questionnaire
Low/High discrimination compared to "none"
Social support measured with Social Support Instrument
All models controlled for socioeconomic disadvantage, gender, race, age, depressive symptoms, stress, diet, smoking, alcohol use, physical activity, and site.



6.5. DISCUSSION

We found that participants with low and high chronic discrimination had lower baseline allostatic load compared to those who reported no chronic discrimination and type of coping was not associated with this relationship. However external coping was associated with lower baseline allostatic load compared to those who did not cope externally, regardless of discrimination level and internal coping was associated with higher allostatic load at baseline compared to those who did not cope internally regardless of discrimination level. Participants who reported high chronic discrimination had a significant increase in allostatic load from baseline to exam 5 compared to those who reported no chronic discrimination. Neither external coping, internal coping, nor social support moderated the relationship between change in allostatic load and amount of discrimination.

Participants with some/low discrimination and high discrimination show significantly lower allostatic load at exam 1 than those who report no discrimination. Although this finding was not expected it is not completely without context in the literature. Previous research has found that those who fail to report discrimination or suffer from "internalized oppression", not considering discrimination to be discrimination because they feel it's deserved, had significantly higher blood pressure than those who reported discrimination.[35, 36] Krieger et al[10] found that among working class, African American men and women, those who had experienced discrimination tended to have lower blood pressure than those who did not. Some have hypothesized that those who have dealt with discrimination successfully have developed coping strategies that preserve their physical and mental health. It is also possible that other common coping strategies utilized by those who suffer from chronic discrimination, such as religious/spiritual based coping[25] and strong ethnic identity[27] are being employed within this sample resulting in a lower allostatic load score. Though there is no way to verify this as those coping mechanisms were not measured. Another possible explanation, delayed association will be discussed below.

External coping was associated with a decrease in baseline allostatic load regardless of discrimination level and internal coping was associated with an increase in allostatic load regardless of discrimination level. Previous research has shown that those who suppress anger related to racial discrimination rather than dealing with it tend to have higher blood pressure.[26] At least one study that used the same measure of discrimination and coping as our study showed that internal coping was associated with higher blood pressure among women but not men even though men tended to use internal coping methods more than women did.[10] In a secondary analysis (not shown) we found similar results with the response "Accept it as a fact of life". More men chose this response but women who selected it were more likely to have an increased allostatic load score. The association between internal coping and poorer physical health measures (blood pressure) appears to be replicated in our study. Although our study did not show a significant association between coping styles and discrimination, the association between coping style and baseline allostatic load may be useful to stimulate further research on how coping with life stress may be associated with physical health. Future research should utilize a more comprehensive coping questionnaire as well as measure of discrimination specific coping

Participants who reported high levels of chronic discrimination show a significantly larger increase in allostatic load from exam 1 to exam 5 than those who reported no discrimination. This finding is particularly interesting in light of the previous finding that discrimination was associated with a decrease in baseline allostatic load. Previous research has shown that discrimination can have a lagged effect on functional limitation[35, 37] and that repeated instances of discrimination are more associated with functional limitations than one instance. The theory of "weathering", that repeated instances of stress weather a person's resistance against subsequent stress, is particularly relevant. Weathering has been associated with allostatic load[13] and as such may help to explain the differing associations that we found in this study. Although we were only able to utilize one measure of chronic discrimination at one point in time, it is possible that subsequent discrimination in the intervening 5 years between exam 1 and exam 5 is partly responsible for the association between change in allostatic load and high discrimination found in this sample even though discrimination was associated with lower baseline allostatic load. Future research should focus on amount of discrimination as well as subjective appraisal of instances of discrimination (how distressing the discrimination is to the individual). Previous research has found shown that among adolescents, emotional support from caregivers buffers the effects of allostatic load over time when perceived discrimination is present.[20] Our results did not show the expected relationship between social support and change in allostatic load. The measure of social support that was used in the current study asked how often someone was available for various support such as help making a tough decision, and someone to talk to. The social support instrument was not discrimination specific and it did not ask how often the participant utilized the support of the person that they had available. Future research could benefit from both of these aspects of social support measurement.

The current study had a few limitations. The chronic discrimination measure was only available at baseline, and although our coping questions were specific to chronic discrimination they weren't extensive. One question measures are not ideal for revealing associations. We also did not have a discrimination specific social support index. Our study also had several strengths. We utilized a reliable and valid method of measuring day to day discrimination, we had a large multi-ethnic sample with cardiometabolic data, and we had multiple time-points of allostatic load data enabling us to look at a change in allostatic load rather than just at baseline.

In conclusion, the relationship between perceived discrimination and allostatic load appears to be complex and dependent upon both physical and social factors. The current study has added to the literature on perceived chronic discrimination by revealing its relationship to change in allostatic load. This study has also helped to illuminate the association between coping and allostatic load. Future research would benefit from multiple measures of discrimination at different time-points, a social support utilization questionnaire, and a measure utilizing subjective appraisal of discrimination. These measures would allow researchers to better understand the relationship between how distressing one finds discrimination and health as well as the relationship between utilization of social support and how it affects the association of discrimination with physical health, both of which are gaps in research that need to be addressed. Although, these gaps remain it is clear from previous research and the current study that discrimination has the potential to be detrimental to physical health in addition to to its proven detriment to psychological health and that adequate social support could be a buffer for that association.

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CHAPTER 7: DISCUSSION OF RESULTS AND POLICY IMPLICATIONS

7.1. OVERALL CONCLUSIONS

This research had three main conclusions: health behaviors, specifically physical activity and alcohol use are associated with indicators of allostatic load; scores on measures of cognitive function appear to be disparate by race, although perceived discrimination and allostatic load did account for a small amount of the variance in the relationship; and finally coping methods and social support did not appear to moderate the relationship between discrimination and allostatic load though coping methods did appear to be associated with allostatic load, independent of amount of discrimination.

7.2. CORRELATES OF COGNITIVE FUNCTIONING

The number of adults who will be of an age where cognitive functioning is a concern is rapidly increasing[1]. Our research indicated that overall, 46% of the variance in cognitive functioning was accounted for by race, allostatic load, discrimination, health behaviors, and the demographic covariates. Specifically race accounted for 10% of the variance and the covariates accounted for 20% of the variance. Conversely, this means that 54% of the variation in cognitive functioning was unaccounted for in our model. This variation could be partially accounted for by coping style, social factors over the life course (e.g. socioeconomic status, multiple instances of discrimination) quality of education, physical factors over the life course (e.g. childhood illness), genetics, and factors that have not yet been studied.

Our research showed a continued relationship between race and cognitive function. Compared to Whites, Blacks and Hispanics had consistently lower cognitive test scores in global cognitive functioning, verbal fluency, processing speed, and working memory. Chinese-American participants showed consistently higher test scores than Whites in all areas except global processing, where they had lower test scores than Whites. These findings are similar to what has been found in prior research.[2, 3] Similarly, we found that allostatic load was significantly higher among Blacks, Hispanics, and Chinese-American compared to Whites. In models grouped by race, the path from These findings are also consistent with previous research,[4-7] however no previous studies have explored the relationship between race and allostatic load simultaneously with the relationship between race and cognitive functioning. We also found that cognitive functioning was associated with perceived discrimination in our sample.

Further we found that allostatic load was significantly associated with cognitive function so that an increase in allostatic load is associated with a corresponding decrease in cognitive test scores. We found this in the full model with all races as well as in race-specific models. Previous research on allostatic load has shown this association among healthy older adults[8] as well as among middle-aged adults.[9-11]

Through this research we have gained a better understanding of some of the factors that may be associated with cognitive functioning, however it is imperative to gain a better understanding of how multiple factors converge to affect cognitive functioning in middle-aged to older adults. Although our research has provided some insight into this variation there is still work to do.

7.3. ALLOSTATIC LOAD

Allostatic load was a key component in all three aims due to the possibility of it being a mechanism through which multiple factors may be associated with cognitive functioning. All three studies showed consistent results with regards to allostatic load, even though the operationalization of the variable differed from aim 1 to aims 2 and 3. Increased physical activity was associated with decreased allostatic load regardless of the sample used and the definition of allostatic load. In the first aim, those who got at least 500 MET-mins/week of intentional physical activity were less likely to be in the metabolic plus blood pressure class than the low class of a latent model of allostatic load. In the second aim, increase in number of MET-min/wk was associated with a decrease in a continuous measure of allostatic load. Previous research has shown this association between physical activity and allostatic load but such research has been limited to either specific ethno-racial groups[12] or the minimum amount of exercise was significantly higher than what was found in this research.[13] One study did find similar results as the current research, though our minimum of intentional exercise was 100 MET-mins/week less and still showed a significant association.[14] The results of the current study are especially relevant in the light of an aging society. Middle-aged and older adults may have difficulty getting a high amount of exercise. Although the reasons may be different, lack of time for the former and physical limitations for the latter, the result is the same. Since our results indicate that middle-aged and older adults can confer benefit from low to moderate amounts of exercise, at least as far as metabolic and blood pressure indicators are concerned, it may be encouraging for these populations to have evidence that they don't have to give up exercising if they can't fit in an hour-long intense session, because consistent moderate exercise may be beneficial as well.

Similar results were found for current alcohol use. Those who endorsed current alcohol use were significantly more likely to be in the low class than the metabolic plus blood pressure class of the latent allostatic load measure and an increase in drinks per week was associated with a decrease in the continuous measure of allostatic load. Again, previous research has shown benefits of low-to-moderate alcohol use[15-17] and our study appears to confirm that finding, though none of the previous studies specifically explored allostatic load as an outcome. More than half of our sample who were current drinkers reported having <=2 drinks per week so the results are clearly not a reason for adults to start drinking every day where they have abstained in the past. However, based on our results, those who do choose to drink moderately may receive metabolic benefits.

Race was also significantly associated with allostatic load in our study. Compared to Whites, Chinese-Americans, Blacks, and Hispanics all had significantly higher allostatic load. Previous research has shown that regardless of education, age, and socioeconomic status, Blacks and Mexicans have higher allostatic load than Whites, with Blacks having the highest of all.[4-7]

Discrimination showed mixed associations with allostatic load. Discrimination at exam 1 was not associated with allostatic load at exam 5, higher discrimination was associated with lower allostatic load at exam 1, and higher discrimination was associated with a larger change in allostatic load from exam 1 to exam 5 (about 5 years). We consider two explanations for the contradictory findings based on the literature. Studies have shown that perceived discrimination can have a lagged effect on functional limitation, meaning that the effect from discrimination takes time to reveal itself. Since our study showed discrimination to be detrimental over time, that is a possible explanation. Another possibility is that discrimination weathers away one's defenses as Geronimus[7] proposes so that a few instances of discrimination are not as detrimental as multiple instances of discrimination. It is plausible that those who reported chronic discrimination in this study continued to contend with chronic discrimination rather than having just the instances that they reported. If that was the case, then the increase in allostatic load over time could conceivably be attributed to multiple instances of chronic discrimination. Finally, as mentioned above, higher allostatic load was detrimental to all aspects of cognitive functioning in our study.

7.4. PERCEIVED DISCRIMINATION

We found, as have others, that perceived discrimination was highest among the Black and Hispanic participants.[18-23] Our path analysis revealed that both lifetime discrimination and daily hassles were significantly lower among Chinese-Americans than among Whites and conversely that both types of discrimination were significantly higher among Blacks compared to Whites.

Hispanics fell in the middle with significantly higher lifetime discrimination than Whites and significantly lower daily hassles than Whites. We also found a very small indirect effect of race on cognitive function through allostatic load.

Although perceived discrimination showed a negative relationship with allostatic load at exam 1 and a positive relationship with change in allostatic load from exam 1 to exam 5, there was not a significant relationship between perceived discrimination and allostatic load at exam 5, 12 years later. We hypothesized that perceived discrimination would be associated with cognitive functioning through its association with allostatic load. However, we found that perceived discrimination was not associated with allostatic load but that it was associated with cognitive functioning directly. The relationship between perceived discrimination and cognitive functioning was complex. Perceived discrimination appeared to have a positive association with cognitive function among all race groups, regardless of the amount of discrimination. Previous studies have shown an increase in cognitive health [24] among Blacks who report racial discrimination and better speed of processing[25] among Blacks who were exposed to blatant discrimination as opposed to ambiguous discrimination. In the former, it's hypothesized that coping skills and resilience may buffer the relationship while in the latter it may be due to less cognitive resources being used when discrimination is recognized as such and not being forced to decide if discrimination is present. These results should not be interpreted to mean that discrimination is good, however, more so that it has been so pervasive over time that people have come up with strategies (conscious or unconscious) to preserve their cognitive functioning.

7.5. COPING

We explored the association between perceived discrimination and allostatic load and how coping might modify that relationship. We assessed the association of external coping (doing something about it, talking to others), internal coping (accepting it as a fact of life, keeping it to oneself), and social support. Among our sample, neither internal or external coping nor amount of social support moderated the relationship between chronic discrimination and allostatic load at exam 1. We had a very limited measure of coping (two questions for internal coping style and two questions for external coping style) so a more extensive measure of coping style may show different results. Independent of level of discrimination, however, coping by “do[ing] something about it” when treated unfairly was associated with a decrease in allostatic load while “accept[ing] it as a fact of life” when treated unfairly was associated with an increase in allostatic load.

Similarly, the association between amount of chronic discrimination and change in allostatic load was not moderated by coping style or social support in our sample. The same caveat regarding the way coping style was measured applies here. Although the social support instrument that was used was a known and validated scale, it was not specific to discrimination and it asked about the availability of social support rather than the utilization of social support.

7.6 FUTURE DIRECTIONS

Further research regarding race, allostatic load, discrimination, coping, and cognitive function are vital to improve our understanding of these relationships. Although it has been shown consistently that race is a predictor of cognitive functioning we are still unable to fully understand why it is a factor and what may account for that variance. Although we used a measure of socioeconomic disadvantage that included wealth and education, we were not able to include neighborhood factors or quality of education. Neighborhood factors have been shown to be associated with physical health regardless of race so it may be a promising avenue for cognitive research. Quality of education, literacy especially, has been shown to be a predictor of cognitive test scores so inclusion of it in a model similar to what has been presented in this research might account for additional variance. This area of research would also benefit from discrimination measures at multiple time points and discrimination specific coping questionnaires.

Cognitive aging research is showing that the groundwork for diseases that affect older adults is laid even earlier than middle age so it is becoming more important to study childhood and youth factors that may be associated with cognitive functioning in adulthood. Since one of the better ways to measure cognition is within person measures (comparing a person's cognitive function to their previous function), a longitudinal study that repeatedly measures discrimination, allostatic load, and cognition would allow for the researcher to gain a better understanding of the association between these variables over time. An understanding of how these variables affect individual trajectories would allow public health researchers to design interventions that would help the most people in the most effective way possible.

7.7. IMPLICATIONS FOR PUBLIC HEALTH POLICY AND RESEARCH

Due to the predicted growth of the minority aging population it is vital that we understand how minorities might be at a disadvantage. Conversely, if minorities have adapted so that they are preserving their cognitive function it is important to understand the strategies that have been successful and try to replicate them. Since stress is so pervasive in American society and allostatic load is a consequence of chronic stress, a better understanding of the role of allostatic load in cognitive aging is necessary. We showed that allostatic load is associated with cognitive aging in a multi-ethnic population, which indicates that allostatic load is a very real issue that needs to be addressed in an aging population. The finding that a low to moderate amount of weekly exercise can benefit middle-aged to older adults in reduction of some aspects of allostatic load contributes to this body of research. Similarly, our findings regarding discrimination and allostatic load, imply that chronic discrimination may have a detrimental effect on allostatic load over a number of years. Since the way that a person copes appears to be associated with allostatic load regardless of amount of discrimination, this too is an avenue of research that may offer hope for the future.

Our results indicate that it may be beneficial to focus public health research in this area on individual factors that may affect cognitive aging. It is also advisable to try to understand what strategies have been employed by those who report perceived discrimination since our results show that presence of discrimination may actually be associated with an increase in cognitive function a decade later. If the strategies that are used to deal with this discrimination are beneficial to cognitive function an intervention using these methods may be beneficial.

Public health policy should focus on health behavior guidelines, such as physical activity, and how they may effect allostatic load. Since stress is so closely linked with increased allostatic load, and by extension with cognitive function, stress management may also be an area for change in public health policy. Stress due to finances, work, childcare, institutional racism, sexism, and so on are all areas that can be addressed by public health policy. Continued research into successful coping methods and interventions designed around these methods are another way in which public health research and practice might improve the lives of middle-aged and older adults. Recognition that our population is aging and that the racial and ethnic make-up is shifting is not enough if we don't continue to study how to best help the population age successfully. We must define "successful aging" in terms of concrete goals and create interventions that allow people to reach those goals. This research has been a first step in better understanding cognitive functioning in middle-aged and older adults and how psychosocial and physical correlates are associated with cognitive functioning.

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APPENDIX A

A.1. CENTER FOR EPIDEMIOLOGIC STUDIES – DEPRESSION SCALE[1]

Health and Life - 4

Id#:

7 Below is a list of the ways you might have felt or behaved. Please indicate how often you felt this way <u>DURING THE PAST WEEK.</u>

			Rarely or none of the time (Less than 1 Day)	Some or a little of the time (1-2 Days)	A moderate amount of the time (3-4 Days)	Most of the time (5-7 Days)
A.	I was bothered by things that don't usually bother me	BOTHER1	1 ○	2 ○	3 ○	4 ○
B.	I did not feel like eating; my appetite was poor	NOTEAT1	1 ○	2 ○	3 ○	4 ○
C.	I felt that I could not shake off the blues, even with help from my family and friends	BLUE1	1 ○	2 ○	3 ○	4 ○
D.	I felt that I was just as good as other people	ASGOOD1	1 ○	2 ○	3 ○	4 ○
E.	I had trouble keeping my mind on what I was doing	CONCNTR1	1 ○	2 ○	3 ○	4 ○
F.	I felt depressed	DEPRESS1	1 ○	2 ○	3 ○	4 ○

			Rarely or none of the time (Less than 1 Day)	Some or a little of the time (1-2 Days)	A moderate amount of the time (3-4 Days)	Most of the time (5-7 Days)
G.	I felt that everything I did was an effort	EFFORT1	1 ○	2 ○	3 ○	4 ○
H.	I felt hopeful about the future	HOPEFUL1	1 ○	2 ○	3 ○	4 ○
I.	I thought my life had been a failure	LFFAIL1	1 ○	2 ○	3 ○	4 ○
J.	I felt fearful	FEARFUL1	1 ○	2 ○	3 ○	4 ○
K.	My sleep was restless	BADSLP1	1 ○	2 ○	3 ○	4 ○
L.	I was happy	HAPPY1	1 ○	2 ○	3 ○	4 ○
M.	I talked less than usual	LESTALK1	1 ○	2 ○	3 ○	4 ○
N.	I felt lonely	LONELY1	1 ○	2 ○	3 ○	4 ○
O.	People were unfriendly	UNFRNLY1	1 ○	2 ○	3 ○	4 ○
P.	I enjoyed life	ENJLIFE1	1 ○	2 ○	3 ○	4 ○
Q.	I had crying spells	CRYSPEL1	1 ○	2 ○	3 ○	4 ○

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A.2. SOCIAL SUPPORT INDEX[2]

Health and Life - 5

Id#:

Below is a list of the ways you might have felt or behaved. Please tell me how often you felt this way <u>DURING THE PAST WEEK.</u>

		Rarely or none of the time (Less than 1 Day)	Some or a little of the time (1-2 Days)	A moderate amount of the time (3-4 Days)	Most of the time (5-7 Days)
R.	I felt sad **SAD1**	1○	2○	3○	4○
S.	I felt that people dislike me **DISLIKD1**	1○	2○	3○	4○
T.	I could not "get going" **GETGOIN1**	1○	2○	3○	4○

Please read the following questions and mark the answer that best describes your life now.

		None of the time	A little of the time	Some of the time	Most of the time	All of the time
8	Is there someone available to you whom you can count on to listen to you when you need to talk? **TALKTO1**	1○	2○	3○	4○	5○
9	Is there someone available to give you good advice about a problem? **ADVICE1**	1○	2○	3○	4○	5○
10	Is there someone available to you who shows you love and affection? **AFFECTN1**	1○	2○	3○	4○	5○
11	Is there someone available to help you with daily chores? **HLPCHR1**	1○	2○	3○	4○	5○
12	Can you count on anyone to provide you with emotional support (talking over problems or helping you make a difficult decision)? **EMOSPT1**	1○	2○	3○	4○	5○
13	Do you have as much contact as you would like with someone you feel close to, someone in whom you can trust and confide? **CONFIDE1**	1○	2○	3○	4○	5○

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A.3. MAJOR EXPERIENCES OF DISCRIMINATION SCALE[3]

Health and Life - 6

Id#:

Now we would like to ask you a few questions about situations where you might have felt that you had been treated unfairly.

14 a. Do you think you have ever been unfairly fired or denied a promotion? 1○ Yes 0○ No **UF1FIRE1**

b. **IF YES:** What was the main reason? (Choose one)

UF2FIRE1

1○ Race or Ethnicity	5○ Physical Appearance
2○ Gender	6○ Sexual Orientation
3○ Age	7○ Income level/Social Class
4○ Religion	8○ Other

c. Did this happen in the last 12 months? 1○ Yes 0○ No **UF3FIRE1**

15 a. For unfair reasons, do you think you have ever not been hired for a job? 1○ Yes 0○ No **UF1HIRE1**

b. **IF YES:** What was the main reason? (Choose one)

UF2HIRE1

1○ Race or Ethnicity	5○ Physical Appearance
2○ Gender	6○ Sexual Orientation
3○ Age	7○ Income level/Social Class
4○ Religion	8○ Other

c. Did this happen in the last 12 months? 1○ Yes 0○ No **UF3HIRE1**

16 a. Have you ever been unfairly stopped, searched, questioned, physically threatened or abused by the police? 1○ Yes 0○ No **UF1STOP1**

b. **IF YES:** What was the main reason? (Choose one)

UF2STOP1

1○ Race or Ethnicity	5○ Physical Appearance
2○ Gender	6○ Sexual Orientation
3○ Age	7○ Income level/Social Class
4○ Religion	8○ Other

c. Did this happen in the last 12 months? 1○ Yes 0○ No **UF3STOP1**

17 a. Have you ever been unfairly discouraged by a teacher or advisor from continuing your education? 1○ Yes 0○ No **UF1EDUC1**

b. **IF YES:** What was the main reason? (Choose one)

UF2EDUC1

1○ Race or Ethnicity	5○ Physical Appearance
2○ Gender	6○ Sexual Orientation
3○ Age	7○ Income level/Social Class
4○ Religion	8○ Other

c. Did this happen in the last 12 months? 1○ Yes 0○ No **UF3EDUC1**

A.4. EVERYDAY DISCRIMINATION SCALE[4]

Health and Life - 7

Id#:

18 a. **Have you ever been <u>unfairly</u> prevented from moving into a neighborhood because the landlord or a realtor refused to sell or rent you a house or apartment?** 1○ Yes 0○ No **UF1MOVE1**

b. **IF YES:** What was the main reason? (Choose one) **UF2MOVE1**

- 1○ Race or Ethnicity
- 2○ Gender
- 3○ Age
- 4○ Religion
- 5○ Physical Appearance
- 6○ Sexual Orientation
- 7○ Income level/Social Class
- 8○ Other

c. Did this happen in the last 12 months? 1○ Yes 0○ No **UF3MOVE1**

19 a. **Have you ever moved into a neighborhood where neighbors made life difficult for you or your family?** 1○ **Yes** 0○ **No** **UF1NGHB1**

b. **IF YES:** What was the main reason? (Choose one) **UF2NGHB1**

- 1○ Race or Ethnicity
- 2○ Gender
- 3○ Age
- 4○ Religion
- 5○ Physical Appearance
- 6○ Sexual Orientation
- 7○ Income level/Social Class
- 8○ Other

c. Did this happen in the last 12 months? 1○ **Yes** 0○ **No** **UF3NGHB1**

In your day-to-day life how often have any of the following things happened to you?

20

	Almost every day	At least once a week	A few times a month	A few times a year	Less than once a year	Never
A. You are treated with less courtesy than other people **CURTESY1**	1○	2○	3○	4○	5○	6○
B. You are treated with less respect than other people **RESPECT1**	1○	2○	3○	4○	5○	6○
C. You receive poorer service than other people at restaurants or stores **SERVICE1**	1○	2○	3○	4○	5○	6○
D. People act as if they think you are not smart **SMART1**	1○	2○	3○	4○	5○	6○
E. People act as if they are afraid of you **AFRAID1**	1○	2○	3○	4○	5○	6○

A.5. COMPONENT FOODS OF FACTOR ANALYSIS FOR DIET VARIABLE[5]

APPENDIX A

Component foods of the 47 food groups used in the factor analysis[1]

Food group	Component foods
Fruit	Peaches, apricots, nectarines, plums, cantaloupe, mango, papaya, strawberries, blueberries, other berries, apples, applesauce, pears, bananas, plantains, oranges, grapefruit, tangerines, kiwi, dried fruits (including raisins, prunes, figs, apricots)
Fruit juices	Orange juice, grapefruit juice, other fruit juice
Avocados and guacamole	Avocado, guacamole
Tomatoes	Tomatoes (cooked or raw), tomato juice, salsa, *pico de gallo,* tomatoes in chile stews,[2] pasta with tomato sauce[2], tomatoes (whole or sauce) in burritos, enchiladas, tamales, or tacos[2]
Vegetables, green leafy	Tossed salad with spinach, romaine or dark greens; cooked spinach; turnip greens; collards
Vegetables, cruciferous	Broccoli, cabbage, cauliflower, Brussels sprouts, sauerkraut, *kimchi,* broccoli and other cruciferous vegetables in stir-fried dishes[2]
Vegetables, dark-yellow	Carrots, winter squash, acorn squash, sweet potatoes, yams, chile peppers in mixed dishes and dark-yellow vegetables in vegetable stir-fried dishes[2]
Vegetables, other	Corn, green beans, peas, snow peas, squash, zucchini, asparagus, mixed vegetables, tossed salad with iceberg or light-green lettuce
Vegetables, potatoes	Boiled, baked, mashed, or other potatoes; turnips; potatoes in meat, chicken, or turkey stew, pot pie, or empanada[2]; pea, lentil, black bean, and potajes soups; pinto, black, baked, butter, or red beans; black-eyed peas; refried beans; beans in enchiladas, tamales, tacos, or burritos[2]
Beans	
Soy foods and beverages	Soy milk, miso soup or sauce with soybean paste, tofu or tempeh in stir-fried dishes
Seeds, nuts, and peanut butter	Almonds, walnuts, pecans, other nuts; sunflower, pinyon, other seeds; peanuts, peanut butter
Whole-grain bread, rice, and pasta	Dark, whole-grain breads or rolls; bran muffins; brown or wild rice; oatmeal; high-fiber cold cereal (by brand name)
Refined-grain bread, rice, and pasta	White bread and rolls, white rice, flour or corn tortillas, other hot cereal, noodles or pasta, refined-grain cold cereal (by brand name)
Eggs and omelets	Eggs, omelets, *huevos rancheros*
Red meat	Hamburger; cheeseburger; meatloaf; hash; beef, pork, or lamb steaks; roasts; barbeque or ribs; red meat in stir-fried and other mixed dishes[2]
Poultry	Roasted, broiled, baked, or ground chicken or turkey; fried chicken; poultry in stir-fried and other mixed dishes[2]
Fish	Shrimp; lobster; crab; oysters, mussels; tuna; salmon; sardines, other broiled, steamed, baked, or raw fish; fish in stir-fried and other mixed dishes[2]
High-fat and processed meats	Ham, hot dogs, bologna, salami, lunchmeats, liver, sausage, chorizo, scrapple, bacon
Fats and oils	Margarine, butter, or oil on vegetables, bread, rice, or pasta; gravies; fried meats (fried chicken, fish, or shrimp)[2]; refried beans (lard used in preparation)[2]
Fried potatoes	French fries, fried potatoes, hash browns
Salty snacks	Potato, corn, or tortilla chips; crackers; pretzels; popcorn
Pizza	Pizza
Pasta and potato salads	Pasta salad, macaroni salad, potato salad, cole slaw
Chicken, tuna, and egg salads	Chicken salad, tuna salad, egg salad
High-fat Chinese dishes	Fried rice, chow mein, Chinese dumplings, spring roll, dim sum, Chinese bun with meat, sausage, and vegetables
Cream soups and chowders	Cream soups, including chowders, potato, and cheese soups
Other soups	Other soups, including vegetable beef, tomato, egg drop, chicken noodle; meat or fish stews, pot pie[2]
Sweet extras	Sugar or honey in coffee or tea, sugar, jelly, jam, molasses, hard candy, licorice, other candy
Sweet breads	Biscuits, other muffins, croissants, corn bread, hush puppies, pancakes, waffles, French toast
Desserts	Pies; pudding; custard; flan; white doughnuts, cookies, cakes, pastries; chocolate doughnuts, cookies, cakes, brownies, candy
Ice cream	Regular ice cream
Low-fat dairy desserts	Frozen yogurt, low-fat ice cream, ice milk, sherbet
Yogurt	Plain yogurt (unflavored), flavored yogurt
Cottage and ricotta cheese	Cottage or ricotta cheese
High-fat cheeses and cheese and cream sauces	Cheddar, American, Chihuahua, Swiss, cream cheese, cheese spreads, pasta with cream sauce or cheese[2]
Coffee and tea creamer	Cream, half-and-half or nondairy creamer in coffee or tea, whole-milk beverages (including milk in caffe latte, café au lait), whole-milk on cereal, milk added to coffee or tea
Whole milk	
Low-fat milk	2%-fat milk and beverages made with 2%-fat milk, skim or 1%-fat milk and beverages made with skim or 1%-fat milk, 2%-fat, 1%-fat, or skim milk on cereal
Meal-replacement drinks	Instant breakfast[3], Ensure[4], Slim Fast[5]
Nondiet soft drinks	Regular soft drinks, soda, sweetened mineral water, nonalcoholic beer
Diet soft drinks and mineral water	Diet soft drinks, unsweetened mineral water
Tea	Black or green tea
Coffee	Coffee (regular or decaffeinated)
Hot chocolate	Hot chocolate
Beer	Beer
Other alcoholic beverages	Wine, liquor, or mixed drinks

[1] Each row represents a single food-frequency questionnaire item.

[2] Stir-fried and other mixed dishes were disaggregated, and component foods were allocated to food groups accordingly.

[3] Nestle/Carnation, Vevey, Switzerland.

[4] Abbott, Abbott Park, IL.

[5] Unilever, Englewood, NJ.

A.6. SAMPLE OF PHYSICAL ACTIVITY TO MET CONVERSION[6]

2011 Compendium of Physical Activities

*Italicized codes and METs are estimated \

CODE	METS	MAJOR HEADING	SPECIFIC ACTIVITIES
01003	14.0	bicycling	bicycling, mountain, uphill, vigorous
01004	16.0	bicycling	bicycling, mountain, competitive, racing
01008	*8.5*	bicycling	bicycling, BMX
01009	*8.5*	bicycling	bicycling, mountain, general
01010	4.0	bicycling	bicycling, <10 mph, leisure, to work or for pleasure (Taylor Code 115)
01011	6.8	bicycling	bicycling, to/from work, self selected pace
01013	5.8	bicycling	bicycling, on dirt or farm road, moderate pace
01015	7.5	bicycling	bicycling, general
01018	3.5	bicycling	bicycling, leisure, 5.5 mph
01019	5.8	bicycling	bicycling, leisure, 9.4 mph
01020	6.8	bicycling	bicycling, 10-11.9 mph, leisure, slow, light effort
01030	8.0	bicycling	bicycling, 12-13.9 mph, leisure, moderate effort
01040	10.0	bicycling	bicycling, 14-15.9 mph, racing or leisure, fast, vigorous effort
01050	*12.0*	bicycling	bicycling, 16-19 mph, racing/not drafting or > 19 mph drafting, very fast, racing general
01060	15.8	bicycling	bicycling, > 20 mph, racing, not drafting
01065	8.5	bicycling	bicycling, 12 mph, seated, hands on brake hoods or bar drops, 80 rpm
01066	9.0	bicycling	bicycling, 12 mph, standing, hands on brake hoods, 60 rpm
01070	*5.0*	bicycling	unicycling
02001	2.3	conditioning exercise	activity promoting video game (e.g., Wii Fit), light effort (e.g., balance, yoga)
02003	3.8	conditioning exercise	activity promoting video game (e.g., Wii Fit), moderate effort (e.g., aerobic, resistance)
02005	7.2	conditioning exercise	activity promoting video/arcade game (e.g., Exergaming, Dance Dance Revolution), vigorous effort
02008	5.0	conditioning exercise	army type obstacle course exercise, boot camp training program
02010	*7.0*	conditioning exercise	bicycling, stationary, general
02011	3.5	conditioning exercise	bicycling, stationary, 30-50 watts, very light to light effort
02012	6.8	conditioning exercise	bicycling, stationary, 90-100 watts, moderate to vigorous effort
02013	8.8	conditioning exercise	bicycling, stationary, 101-160 watts, vigorous effort
02014	11.0	conditioning exercise	bicycling, stationary, 161-200 watts, vigorous effort
02015	14.0	conditioning exercise	bicycling, stationary, 201-270 watts, very vigorous effort
02017	4.8	conditioning exercise	bicycling, stationary, 51-89 watts, light-to-moderate effort
02019	8.5	conditioning exercise	bicycling, stationary, RPM/Spin bike class
02020	*8.0*	conditioning exercise	calisthenics (e.g., push ups, sit ups, pull-ups, jumping jacks), vigorous effort
02022	3.8	conditioning exercise	calisthenics (e.g., push ups, sit ups, pull-ups, lunges), moderate effort
02024	2.8	conditioning exercise	calisthenics (e.g., situps, abdominal crunches), light effort
02030	3.5	conditioning exercise	calisthenics, light or moderate effort, general (e.g., back exercises), going up & down from floor (Taylor Code 150)
02035	4.3	conditioning exercise	circuit training, moderate effort
02040	8.0	conditioning exercise	circuit training, including kettlebells, some aerobic movement with minimal rest, general, vigorous intensity
02045	3.5	conditioning exercise	Curves[TM] exercise routines in women
02048	5.0	conditioning exercise	Elliptical trainer, moderate effort
02050	6.0	conditioning exercise	resistance training (weight lifting, free weight, nautilus or universal), power lifting or body building, vigorous effort (Taylor Code 210)
02052	5.0	conditioning exercise	resistance (weight) training, squats , slow or explosive effort
02054	3.5	conditioning exercise	resistance (weight) training, multiple exercises, 8-15 repetitions at varied resistance
02060	5.5	conditioning exercise	health club exercise, general (Taylor Code 160)
02061	5.0	conditioning exercise	health club exercise classes, general, gym/weight training combined in one visit
02062	7.8	conditioning exercise	health club exercise, conditioning classes
02064	3.8	conditioning exercise	home exercise, general
02065	*9.0*	conditioning exercise	stair-treadmill ergometer, general
02068	12.3	conditioning exercise	rope skipping, general
02070	*6.0*	conditioning exercise	rowing, stationary ergometer, general, vigorous effort
02071	4.8	conditioning exercise	rowing, stationary, general, moderate effort

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Table B.1 Standardized path parameters by race and cognitive test

Parameters	White	Chinese	Black	Hispanic
Total Cognition				
Physact -> AL	-0.06*	0.01	-0.07*	-0.02
Alc -> AL	-0.03	0.00	-0.03	-0.06
Diet -> AL	0.09*	-0.09	0.01	0.04
Lifedisc -> Physact	0.05	0.01	0.04	0.11*
DHassles -> Physact	-0.01	-0.03	0.01	0.11*
Lifedisc -> Diet	0.04	0.05	0.10*	0.07*
DHassles -> Diet	0.10*	0.13*	0.06	0.15*
Lifedisc -> Smoke	0.04	0.03	0.06	0.06
DHassles -> Smoke	0.02	0.03	0.02	0.11*
Lifedisc -> Alc	0.02	0.06	-0.01	-0.08*
DHassles -> Alc	0.03	-0.01	0.06	-0.04
Lifedisc -> Cognition	0.05*	0.10*	0.06*	0.03
DHassles -> Cognition	0.03	0.10*	0.09*	0.07*
AL -> Cognition	-0.08*	-0.10*	-0.09*	-0.10*
Digit Span				
Physact -> AL	-0.06*	0.02	-0.08*	-0.03
Alc -> AL	-0.04	0.01	0.01	-0.06
Diet -> AL	0.08*	-0.08	0.00	0.03
Lifedisc -> Physact	0.05*	0.00	0.04	0.10*
DHassles -> Physact	-0.01	-0.03	0.01	0.12*
Lifedisc -> Diet	0.03	0.01	0.12*	0.07*
DHassles -> Diet	0.10*	0.14*	0.06	0.16*
Lifedisc -> Smoke	0.05*	0.07	0.06	0.06
DHassles -> Smoke	0.03	0.01	0.03	0.12*
Lifedisc -> Alc	0.02	0.01	-0.01	-0.07*
DHassles -> Alc	0.02	-0.03	0.05	-0.03
Lifedisc -> Cognition	0.03	0.00	0.00	0.04
DHassles -> Cognition	0.04	0.03	0.03	0.06
AL -> Cognition	-0.04	-0.01	-0.08*	-0.09*
Digit Symbol				
Physact -> AL	-0.05*	0.01	-0.07*	-0.03
Alc -> AL	-0.04	-0.01	-0.04	-0.06
Diet -> AL	0.09*	-0.08	0.01	0.04
Lifedisc -> Physact	0.04	0.02	0.05	0.11*
DHassles -> Physact	-0.02	-0.03	0.01	0.08*
Lifedisc -> Diet	0.04	0.06	0.09*	0.08*
DHassles -> Diet	0.11*	0.13*	0.05	0.15*
Lifedisc -> Smoke	0.05	0.03	0.05	0.06
DHassles -> Smoke	0.03	0.02	0.02	0.11*
Lifedisc -> Alc	0.02	0.04	-0.02	-0.07*
DHassles -> Alc	0.02	-0.02	0.05	-0.04
Lifedisc -> Cognition	-0.01	0.02	0.06*	0.05
DHassles -> Cognition	0.02	0.10*	0.06*	0.10*
AL -> Cognition	-0.06*	-0.12*	-0.09*	-0.10*
CASI				
Physact -> AL	-0.06*	0.02	-0.08*	-0.03
Alc -> AL	-0.04	0.00	0.01	-0.06
Diet -> AL	0.08*	-0.09	0.01	0.04
Lifedisc -> Physact	0.05*	-0.01	0.04	0.10*
DHassles -> Physact	-0.01	-0.04	0.02	0.12*
Lifedisc -> Diet	0.03	0.05	0.12*	0.07*
DHassles -> Diet	0.10*	0.13*	0.07*	0.15*
Lifedisc -> Smoke	0.04	0.01	0.07*	0.06
DHassles -> Smoke	0.03	0.02	0.03	0.11*
Lifedisc -> Alc	0.02	0.05	-0.01	-0.08*
DHassles -> Alc	0.01	0.00	0.05	-0.04
Lifedisc -> Cognition	0.05*	0.10*	0.06	0.00

DHassles -> Cognition	0.04	0.10*	0.11*	0.02
AL -> Cognition	-0.04	-0.11*	0.00	-0.08

TABLE B.2. MAXIMUM LIKELIHOOD ESTIMATES FOR FINAL MODEL OF RACE, DISCRIMINATION, AND CASI SCORE (N=4320)

PARAMETERS	Unstandardized	SE	Standardized
LIFETIME DISCRIMINATION			
CHINESE V. WHITE	-0.16*	0.06	-0.15
BLACK V. WHITE	0.74*	0.04	0.69
HISPANIC V. WHITE	0.21*	0.05	0.20
DAILY HASSLES			
CHINESE V. WHITE	-0.08	0.05	-0.08
BLACK V. WHITE	0.46*	0.04	0.46
HISPANIC V. WHITE	-0.07	0.04	-0.07
RACE →PHYS ACT			
CHINESE V. WHITE	-0.15*	0.06	-0.15
BLACK V. WHITE	0.07	0.04	0.07
HISPANIC V. WHITE	0.08	0.05	0.08
RACE →ALC USE			
CHINESE V. WHITE	-3.86*	0.30	-0.70
BLACK V. WHITE	-1.84*	0.21	-0.34
HISPANIC V. WHITE	-2.01*	0.24	-0.37
RACE →DIET			
CHINESE V. WHITE	-1.57*	0.10	-0.82
BLACK V. WHITE	-0.27*	0.07	-0.14
HISPANIC V. WHITE	-0.58*	0.09	-0.30
RACE →SMOKING			
CHINESE V. WHITE	-10.02*	1.13	-0.50
BLACK V. WHITE	-3.40*	0.78	-0.17
HISPANIC V. WHITE	-9.08*	0.90	0.46
RACE →AL			
CHINESE V. WHITE	0.40	0.21	0.12
BLACK V. WHITE	0.38*	0.14	0.11
HISPANIC V. WHITE	0.95*	0.16	0.27
RACE → COGNITION (CASI)			
CHINESE V. WHITE	-0.42*	0.05	-0.43
BLACK V. WHITE	-0.43*	0.33	-0.44
HISPANIC V. WHITE	-0.56*	0.04	-0.57
DISC→PHYS ACT			
LIFETIME DISC	0.05*	0.02	0.05
DAILY HASSLES	0.04*	0.02	0.04
DISC→DIET			
LIFETIME DISC	0.12*	0.03	0.07
DAILY HASSLES	0.18*	0.03	0.10
DISC→SMOKING			
LIFETIME DISC	0.89*	0.30	0.05
DAILY HASSLES	0.91*	0.33	0.05
DISC→COGNITION (CASI)			
LIFETIME DISC	0.04*	0.01	0.05
DAILY HASSLES	0.06*	0.01	0.06
AL→COGNITION (CASI)	-0.01*	0.00	-0.05
PHYS ACT → AL	-0.17*	0.05	-0.05
ALCOHOL→ AL	-0.02	0.01	-0.03
DIET→ AL	0.08*	0.03	0.05

*P<0.05

ALL MODELS CONTROL FOR SOCIOECONOMIC DISADVANTAGE, AGE, STRESS, DEPRESSIVE SYMPTOMS, SEX AND SITE

TABLE B.3. MAXIMUM LIKELIHOOD ESTIMATES FOR FINAL MODEL OF RACE, DISCRIMINATION, AND DIGIT SYMBOL SUBSTITUTION TEST SCORE (N=4015)

PARAMETERS	Unstandardized	SE	Standardized
LIFETIME DISCRIMINATION			
CHINESE V. WHITE	-0.15	0.06	-0.14
BLACK V. WHITE	0.74	0.04	0.69
HISPANIC V. WHITE	0.21	0.05	0.20
DAILY HASSLES			
CHINESE V. WHITE	-0.04	0.05	-0.04
BLACK V. WHITE	0.48*	0.03	0.47
HISPANIC V. WHITE	0.01	0.04	0.01
RACE →PHYS ACT			
CHINESE V. WHITE	-0.11	0.06	-0.11
BLACK V. WHITE	0.05	0.04	0.05
HISPANIC V. WHITE	0.07	0.05	0.07
RACE →ALCOHOL USE			
CHINESE V. WHITE	-3.86*	0.29	-0.73
BLACK V. WHITE	-1.86*	0.22	-0.35
HISPANIC V. WHITE	-2.00*	0.24	-0.38
RACE →DIET			
CHINESE V. WHITE	-1.59*	0.10	-0.83
BLACK V. WHITE	-0.34*	0.08	-0.18
HISPANIC V. WHITE	-0.63*	0.09	-0.33
RACE →SMOKING			
CHINESE V. WHITE	-9.88*	1.10	-0.51
BLACK V. WHITE	-3.34*	0.83	-0.17
HISPANIC V. WHITE	-8.75*	0.90	-0.45
RACE →AL			
CHINESE V. WHITE	0.40*	0.21	0.12
BLACK V. WHITE	0.40*	0.15	0.11
HISPANIC V. WHITE	0.99*	0.16	0.29
RACE → COGNITION (DSS)			
CHINESE V. WHITE	0.10*	0.04	0.11
BLACK V. WHITE	-0.43*	0.03	-0.42
HISPANIC V. WHITE	-0.41*	0.04	-0.42
DISC→PHYS ACT			
LIFETIME DISC	0.05*	0.02	0.06
DAILY HASSLES	0.02	0.02	0.02
DISC→DIET			
LIFETIME DISC	0.11*	0.03	0.07
DAILY HASSLES	0.18*	0.03	0.10
DISC→SMOKE			
LIFETIME DISC	0.92*	0.31	0.05
DAILY HASSLES	0.82*	0.32	0.05
DISC→COGNTION (DSS)			
LIFETIME DISC	0.03*	0.01	0.03
DAILY HASSLES	0.06*	0.01	0.06
AL→COGNITION (DSS)	-0.02	0.00	-0.08
PHYS ACT → AL	-0.14*	0.06	-0.04
ALCOHOL→ AL	-0.02*	0.01	-0.04
DIET→ AL	0.10*	0.03	0.05

*P<0.05

ALL MODELS CONTROL FOR SOCIOECONOMIC DISADVANTAGE, AGE, STRESS, DEPRESSIVE SYMPTOMS, SEX, AND SITE

TABLE B.4. MAXIMUM LIKELIHOOD ESTIMATES FOR FINAL MODEL OF RACE, DISCRIMINATION, AND DIGIT SPAN TOTAL SCORE (N=4423)

PARAMETERS	Unstandardized	SE	Standardized
LIFETIME DISCRIMINATION			
CHINESE V. WHITE	-0.16*	0.06	-0.15
BLACK V. WHITE	0.75*	0.04	0.69
HISPANIC V. WHITE	0.22*	0.05	0.20
DAILY HASSLES			
CHINESE V. WHITE	-0.08	0.05	-0.08
BLACK V. WHITE	0.46*	0.04	0.46
HISPANIC V. WHITE	-0.06	0.04	-0.06
RACE →PHYS ACT			
CHINESE V. WHITE	-0.12*	0.06	-0.12
BLACK V. WHITE	0.06	0.04	0.06
HISPANIC V. WHITE	0.07	0.05	0.07
RACE →ALCOHOL USE			
CHINESE V. WHITE	-3.83*	0.29	-0.70
BLACK V. WHITE	-1.82*	0.20	-0.34
HISPANIC V. WHITE	-2.00*	0.24	-0.37
RACE →DIET			
CHINESE V. WHITE	-1.59*	0.10	-0.83
BLACK V. WHITE	-0.27*	0.08	-0.14
HISPANIC V. WHITE	-0.62*	0.08	-0.32
RACE →SMOKING			
CHINESE V. WHITE	-10.11*	1.09	-0.51
BLACK V. WHITE	-3.81*	0.79	-0.19
HISPANIC V. WHITE	-9.44*	0.89	-0.48
RACE →AL			
CHINESE V. WHITE	0.37	0.20	0.11
BLACK V. WHITE	0.35*	0.13	0.10
HISPANIC V. WHITE	0.95*	0.16	0.27
RACE → COGNITION (DST)			
CHINESE V. WHITE	0.48*	0.05	0.48
BLACK V. WHITE	-0.35*	0.03	-0.35
HISPANIC V. WHITE	-0.77*	0.04	-0.77
DISC→PHYS ACT			
LIFETIME DISC	0.05*	0.02	0.05
DAILY HASSLES	0.03*	0.02	0.03
DISC→DIET			
LIFETIME DISC	0.13*	0.03	0.07
DAILY HASSLES	0.19*	0.03	0.10
DISC→SMOKE			
LIFETIME DISC	0.92*	0.30	-0.01
DAILY HASSLES	0.93*	0.32	0.05
DISC→COGNITION (DST)			
LIFETIME DISC	0.04*	0.01	0.04
DAILY HASSLES	0.05*	0.02	0.05
AL→COGNITION (DST)	-0.02*	0.00	-0.06
PHYS ACT → AL	-0.17*	0.05	-0.05
ALCOHOL→ AL	-0.02	0.01	-0.03
DIET→ AL	0.07*	0.03	0.04

*P<0.05

ALL MODELS CONTROL FOR SOCIOECONOMIC DISADVANTAGE, AGE, STRESS, DEPRESSIVE SYMPTOMS, SEX, AND SITE

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Publications

Forrester, S.N., Gallo, J.J., Smith, G.S., Leoutsakos, J.M.S. (2015). Patterns of neuropsychiatric symptoms in mild cognitive impairment and risk of dementia. Am J Geriatr Psychiatry. doi: 10.1016/j.jagp.2015.05.007

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Posters

Forrester, SN., Leoutsakos, JMS. (2015). Sex differences in neuropsychiatric symptoms in MCI and risk of dementia. Alzheimer's Association International Conference, July 21, 2015; Washington, DC.

Awards

Trainee, T 32 AG027668-06, ALBERT, MARILYN S. (PI) Research Training in Age-Related Cognitive Disorders (Johns Hopkins University School of Public Health

Diversity Supplement to R01 – PE00002598 - ADvance: a 12-month double-blind randomized, controlled feasibility study to evaluate the safety, efficacy, and tolerability of deep brain stimulation of the fornix (DBS-f) in patients with mild probable Alzheimer's disease [ADvance Study], Constantine Lyketsos (PI) (Johns Hopkins University School of Medicine)

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Research Assistant – Johns Hopkins University School of Medicine
Statistical and data support to an epidemiologist and a biostatistician in the department of neuropsychiatry

Research Program Assistant – Johns Hopkins University School of Public Health
Research interview and health navigator for a Cancer disparities program