Effects of Socioeconomic Status on Health Behaviors, Awareness Of and Attitudes Towards Cardiovascular Health Risk Factors Among Spelman College Students

Thesis by

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In Partial Fulfillment of the Requirements
for Institutional Honors

Spelman College
Atlanta, GA

2018
Graduation May 20, 2018

Abstract

According to the American Heart Association, Cardiovascular disease (CVD) remains the number 1 killer of Americans and presents a disproportionate toll on racial/ethnic minority populations [1] because of complex factors such as income and education[2]. These complex factors may contribute to why CVD death rates are 33% higher for blacks than for the overall population in the United States[1]. Therefore, the purpose of this research is to determine whether socioeconomic status (SES), which is primarily measured by income, education, and/or occupation [3] , impacts Spelman College students' health behaviors, their level of awareness of the risk of cardiovascular disease, and their attitudes towards lifestyle habits that may contribute to or prevent the disease. Furthermore, I would also like to understand the effects of obesity at the molecular level. Risk factors of CVD include high blood pressure, obesity, Type 2 Diabetes, and High Cholesterol [4]. The mechanisms behind cardiovascular disease and its risk factors were first researched to better explain why this research is important. Based on student questionnaire, household income, not education of parents, primarily impacts Spelman College students health behaviors, their level of awareness of the risk of cardiovascular disease, and their attitudes towards lifestyle habits that may contribute to or prevent the disease. Based on real time PCR, I found that mRNA expression of mitofusin 2, the mitochondrial fusion regulator decreased 32% in response to increasing doses of resistin. Expression of the other regulators of mitochondrial fusion and fission were unchanged following resistin treatment. These questionnaire data and RASM study data suggest that a lower household income, and the effect of the hormone resistin on mitochondrial fragmentation protein contribute to the development of cardiovascular disease.

Introduction

Cardiovascular Disease or heart disease, includes many problems that often involve atherosclerosis [5]. Endothelial cells that line blood vessels provide a semi-permeable barrier that balances the exchange of fluid, nutrients, gases, and waste between the blood and tissues [5]. These cells also provide a surface that typically allows cellular elements of the blood to flow without sticking to the vessel unless some injury has occured. Endothelial cells, in response to distress, secrete cytokines that trigger and sustain an inflammatory response [5]. Atherosclerosis begins when there is an injury or a disturbance to the endothelial cell layer of arteries [5]. These disturbances can include hypertension, high cholesterol, and chronically elevated blood glucose levels, all of which are risk factors for cardiovascular disease [5]. In response to these triggering factors, leukocytes migrate and adhere to the endothelial cells as an initial step of the inflammatory response [5]. The leukocytes migrate beneath the endothelial cells and as a result, the endothelial cells change their shape and loosen their tight junctions [5]. As a result, there is an increase in the endothelial permeability to fluid, lipids, and leukocytes [5]. Low-density lipoprotein (LDL) enter the arterial wall (into the intima) and undergo oxidation [5]. Macrophages which are activated by the presence of LDL, phagocytose the oxidised LDL [5]. Macrophages, filled with the lipids they take up are referred to as “foam cells”, eventually undergo apoptosis. Since the triggers are present (for example high levels of LDL or hypertension) the lipids continue to accumulate in the intima and the inflammatory process persists [5].

Atherosclerosis is a degenerative process that takes place over years, even decades. Fatty streaks are the first signs of atherosclerosis that can be seen without magnification and occur in the aorta and coronary arteries of most people by age 20 [5]. The fatty streaks consist of foam cells in the arterial wall just below the endothelium.[5] Over time, these streaks can evolve into atherosclerotic plaques, remain stable or even regress.[5] If these fatty streaks evolve into atherosclerotic plaques, they will thicken the walls of the arteries and hinder blood flow, which is a vital event to survival. [5] Possible disturbances to cause this entire inflammatory response include hypertension, high cholesterol, and chronically elevated blood glucose levels, which are all risk factors of cardiovascular disease. [5]

As stated in a review by Swift et al [6], there is an extremely high prevalence of overweight/obesity in Western society and, particularly in patients with Coronary Heart Disease (CHD). In the Navar et al [7] study, it is established that a sedentary lifestyle is a major modifiable risk factor for CHD. Several observational studies have shown that formal Cardiac Rehabilitation and Exercise Training (CRET) promotes safe, successful weight reduction and weight maintenance especially with people who have metabolic syndrome.[6] Metabolic syndrome (MetSyn) is a condition where an individual has combined CVD risk factors of hypertension, high blood sugar, unhealthy cholesterol levels, and abdominal fat. [6] Lavie found when CRET was prescribed to individuals who have MetSyn and CHD, there was a 37% reduction in the prevalence of MetSyn.[6] Many Americans have MetSyn because the American diet is high in salt and fat and Americans eat large portions.[6] It is also beneficial to understand the effects of obesity at the molecular level.

Impaired mitochondrial dynamics have been shown to lead to vascular disease [8]. The mitochondrion is the “powerhouse” of all cells because it converts oxygen and nutrients into adenosine triphosphate (ATP), which is the chemical energy that powers the cell’s metabolic activity . Without mitochondria, there would be less survival of larger animals and humans because efficiency of producing energy would decrease. Mitochondria maintain their homeostasis through fission and fusion, a process called mitochondrial dynamics [9]. Mitochondrial fusion is regulated by the OPA1 and Mfn2 genes and mitochondrial fission is regulated by the Drp1 and Fis1 genes [9]. There has been evidence that people who are obese have impaired mitochondrial dynamics; there is an imbalance of fused and fragmented mitochondria [8]. Adipocytes, or fat cells, secrete a hormone called resistin and it correlates with vascular disease [8]. Therefore, it is also important to determine the effect of resistin on the expression of the mitochondrial dynamics protein machinery.

Cardiovascular disease has many modifiable and non-modifiable risk factors [4]. While this study will focus on the modifiable risk factors such as hypertension, obesity, high cholesterol, and Type II Diabetes, it is important to note non-modifiable risk factors that contribute to this disease [4]. Aging, gender, family history, and ethnicity are all non-modifiable risk factors of cardiovascular disease [4]. With aging comes inevitable narrowing of the arteries which increases the risk of developing CVD [4]. In general, men have a higher risk for heart attack than women, but after women reach menopause and their estrogen levels drop, the gap narrows [4]. If CVD runs in the family and therefore in the genes, it places individuals at a higher risk of also developing cardiovascular disease [4]. Unfortunately, there is nothing that can be done to “reduce” these risk factors however, various studies show that the modifiable risk factors which include obesity, hypertension, high cholesterol, and Type II Diabetes can be improved and even eliminated through lifestyle changes including physical activity and healthy diet [4]. While these lifestyle changes may appear easy to achieve, researchers have found that as socioeconomic status increases, heart disease mortality decreases [3]. This means economic and social factors also contribute to making lifestyle changes.

According to a study conducted by Williams et al [3], heart disease mortality decreases as socioeconomic status increases. Socioeconomic status (SES) measures income, education, and/or occupational status and “is among the most robust of determinants of variations in health outcomes in virtually every society throughout the world” [3]. SES impacts individual’s lifestyle choices such as choosing healthy, nutritious foods. In Ver Ploeg’s study, food deserts are defined as residential areas with limited access to affordable and nutritious food [10]. Cooksey-Stowers asserts that living in a food desert is linked to a poor diet and greater risk of obesity, a modifiable risk factor of CVD [11]. As stated in a report from the Centers for Disease Control and Prevention, 48% of African American (AA) women have heart disease and are at twice as high risk of dying from the disease [12]. SES is likely to play a key role in generating this discrepancy. The goal of this project is twofold: 1) to evaluate how obesity affects the body at a molecular level by changing the mitochondrial metabolism and 2) to determine the impact of SES on their health behaviors, level of awareness of the risk of CVD, and attitudes towards lifestyle habits that may contribute to or prevent the disease within AA female population. Thus in this study, I examined the effects of the hormone resistin on mitochondrial fusion and fission gene expression and I gave 39 Spelman students a questionnaire to determine if SES impacts their health behaviors, level of awareness of the risk of CVD, and their attitudes towards lifestyle habits that may contribute to or prevent the disease.

Methods

Student Questionnaire

The questionnaire cohort consisted of 39 African American women attending Spelman College, classified as sophomore or senior, and enrolled in Sophomore/Senior Seminar course, (ages 18-22). Students were provided with information about the nature of the survey and type of questions it would consist of. Once the consent form was signed, the students responded to the questions in the survey (skipping those they were not willing to address for any reason). Questions consisted of demographic information such as age and hometown, plus a series of questions on: general health, behaviors, lifestyle habits, dietary patterns, socioeconomic status, and general attitudes towards health. For analysis purposes, Yes and No questions were coded to "1" and "2" respectively. Some questions assessing attitudes towards health habits and lifestyle choices were using four-level Likert Scale ranging from: "Strongly Agree," "Agree," "Disagree," and "Strongly Disagree". In order to measure participant's self-perceived sense of health status, body image, and risk of CVD. "Strongly Agree" was coded as "1," "Agree" to "2", "Disagree" to "3," and "Strongly Disagree" to "4."

Rat Aortic Smooth Muscle Cell Culture

Rat aortic smooth muscle cells (RASM) were purchased from Lonza and cultured in Dulbecco's Modified Eagle's Medium F/12 media supplemented with 10% Fetal Bovine Serum (FBS) and 1% Penicillin/Streptomycin at 37℃ and 5% CO_2. Cells were used at passages 6-12 and serum-starved for 48 hours before stimulation with vehicle control or rat recombinant resistin (Bio Vision).

Resistin and Cell Treatments

To determine the effect of resistin on the expression of mitochondrial dynamic genes, 70-80% confluent RASM were serum-starved in Opti-MEM for 48 hours (FBS was removed for stimulation of cells). For the dose response study, cells were stimulated with varying doses of resistin (0 ng/ml, 10 ng/ml, 25 ng/ml, and 60 ng/mL) for 2 hours and then the cells were harvested and used for gene expression analysis.

Quantitative RT-PCR

To determine the effects of resistin on mitochondrial fission and fusion proteins, RNA was extracted from RASM stimulated with vehicle or resistin using an RNeasy mini kit (Qiagen) following the manufacturer's protocol. cDNA was produced by reverse transcription from mRNA using the iScript cDNA synthesis kit (BioRad). RT-PCR was performed using the LightCycler® FastStart DNA Master SYBR Green I. The mRNA analyzed included: Mfn2, Opa1, Drp1, and Fis1 and mRNA expression was normalized to Beta actin (control).

Statistical Analysis

Questionnaire Study

SPSS was utilized to analyze questionnaire data. Statistical significance was set at a probability value $p<0.05$. Correlations were determined by R (Pearson) score from trend lines used in the graphs. R scores were converted to p-values using an online calculator.

RASM Study

Data is the mean of three dose-response experiments +/- the standard error of the mean. Statistical significance was set at a probability value $p<0.05$.

Results

Questionnaire Study

Based on the self-reported values, the study population consists of student's ranging in age between 18 to 22 years old, with an average of 20.62+/-1.23 years old (Table 1). The average weight of the students is 156.79+/-50.53 lbs and the average height is 63.99+/-2.80 inches (Table 1). For African American women of all ages, the national average weight and height are 188 lbs and 5 feet and 4 inches [13]. BMI decreased as participant's parental/guardian highest education level increased (**Figure 1A**). There is significant direct correlation between highest education level and BMI (N=38, R^2=0.372, p=0.022) . BMI did not significantly change as participant's household income changed. There was no significant correlation (N=25, **Figure 1B**). Percent of students who were normal/underweight and overweight/obese were compared to parent/guardian highest education level. Bachelor's degree category has a higher percent of overweight/obese participants (**Figure 1C**).

Participants were asked about their childhood intake of grains, fruits, vegetables, and protein with every meal. Answer choices were "yes, I ate grains, fruits, vegetables, and protein with every meal" and "no, I did not eat grains, fruits, vegetables, and protein with every meal." Parental/guardian highest education level did not affect participant's intake of grains, fruits, vegetables, and protein as children (**Figure 2A**). N=38. The relationship between the two variables was not significant.. Household income affected participant's intake of grains, fruits, vegetables, and protein as children. (**Figure 2B**). There was a significant direct correlation between household income and fruit, vegetable and grain consumption as a child (N=25, R^2= 0.8963, p<0.00001). Participants were asked about their current physical activity level in college. Answer choices ranged from "very active," "active," "moderately active," "somewhat active," and "I do not like to exercise." Parent/guardian highest level of education did not have an effect on student's physical activity level. There was no significant correlation detected (**Figure 2C**). Household income had an effect on student's physical activity level. There was significant direct correlation between household income and the student's physical activity level (N=24, R^2=0.8963, p<0.00001, **Figure 2D**).

Participants were asked about their immediate and extended family member's cardiovascular health. (High Blood Pressure, Stroke, Type 2 Diabetes, High Cholesterol, and Heart Disease). Parental/guardian highest level of education did not have an effect on participant's immediate and extended family average number of CVD risk factors. There was no significant correlation (**Figure 3A**). Household income also did not have an effect on participant's immediate and extended family average number of CVD risk factors. There was no significant correlation (**Figure 3B**). Participants were asked if they thought they were at risk of developing cardiovascular disease. The answer choices were "Agree" or "Disagree." Highest education level of participant's parents affected participant's awareness of developing CVD. There was significant inverse correlation between the highest level of education and awareness of risks of CVD (N=37, R^2= 0.45, p=0.0052, **Figure 3C**). Household income also affected participant's awareness of developing CVD. in this case a significant direct correlation was observed between the two variables ($R^2 = 0.891$, N=25, $p<0.00001$; **Figure 3D**).

Questionnaire Study Tables and Figures

Table 1. Characteristics of the Sample population in comparison to national average.

Sample Population Average	Sample Population **age = 20.62 +/- 1.23 years**	National Average Age: Adult Women 20 and older National Adult Women 20 and over Average BMI:
Average Weight [lbs] Mean +/- SD	156.79 +/- 50.53	188[13]
Average Height [in]	63.99 +/- 2.80	64[13]
Average BMI	26.72 +/- 7.69	32.3*

*18.5-24.9=Healthy BMI, 25-29.9=Overweight, 30.0+=Obese

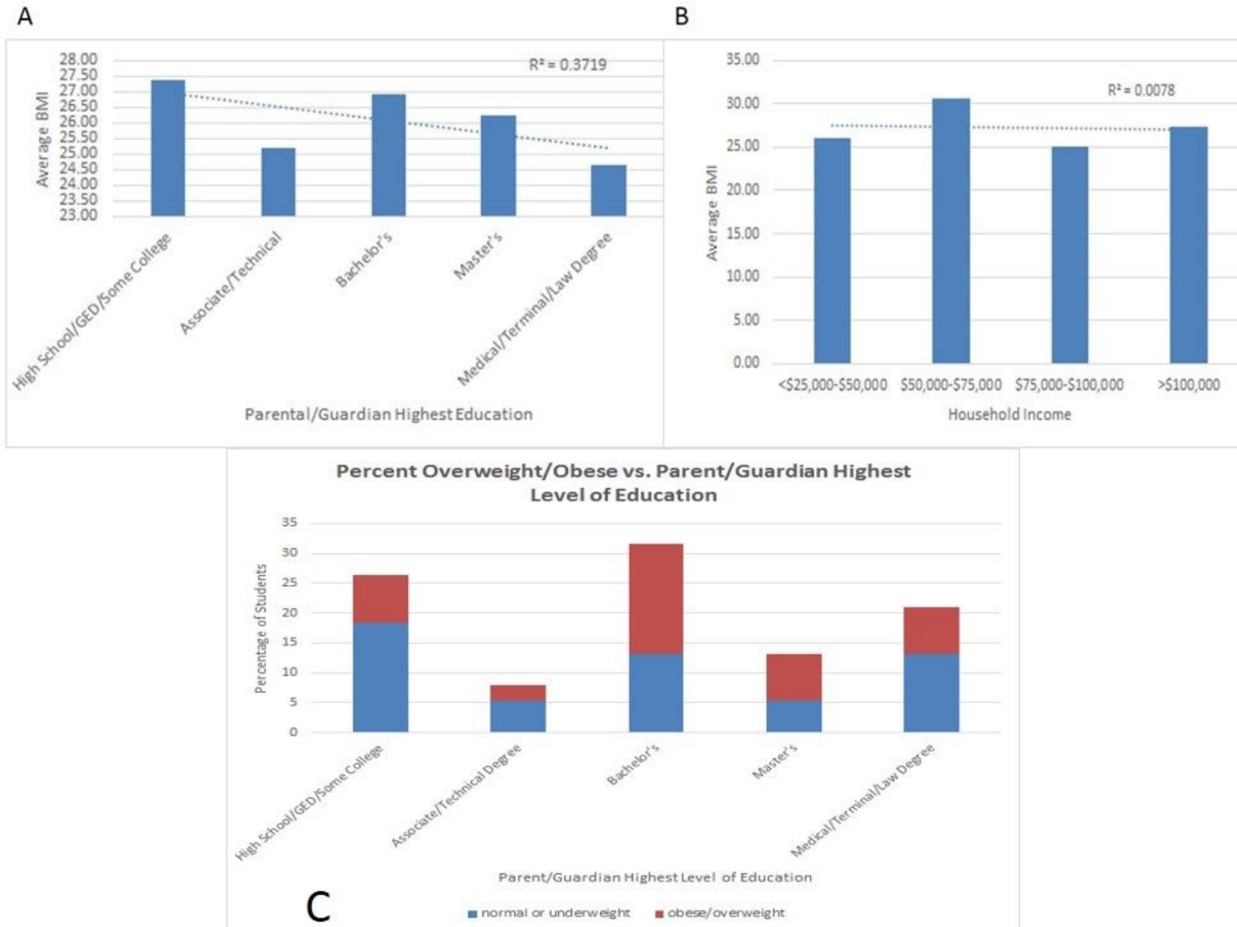

Figure 1. Relationship between highest education, household income, and BMI. A: Comparing average BMI to participant's parent/guardian highest education level. Bars represent mean BMI in specific category. Correlation between participant's parent/guardian highest education level to BMI is significant (N=38.R^2=0.372, p=0.022). **B:** Comparing average BMI to participant's household income. Bars represent mean BMI in each specific category. The correlation is not significant (N=25). **C:** Graph demonstrates percentage of students who are normal or underweight and obese or overweight in each category of parental/guardian highest level of education. Bars represent percentage of students in category of either normal/underweight or overweight/obese. The correlation is not significant (N=38).

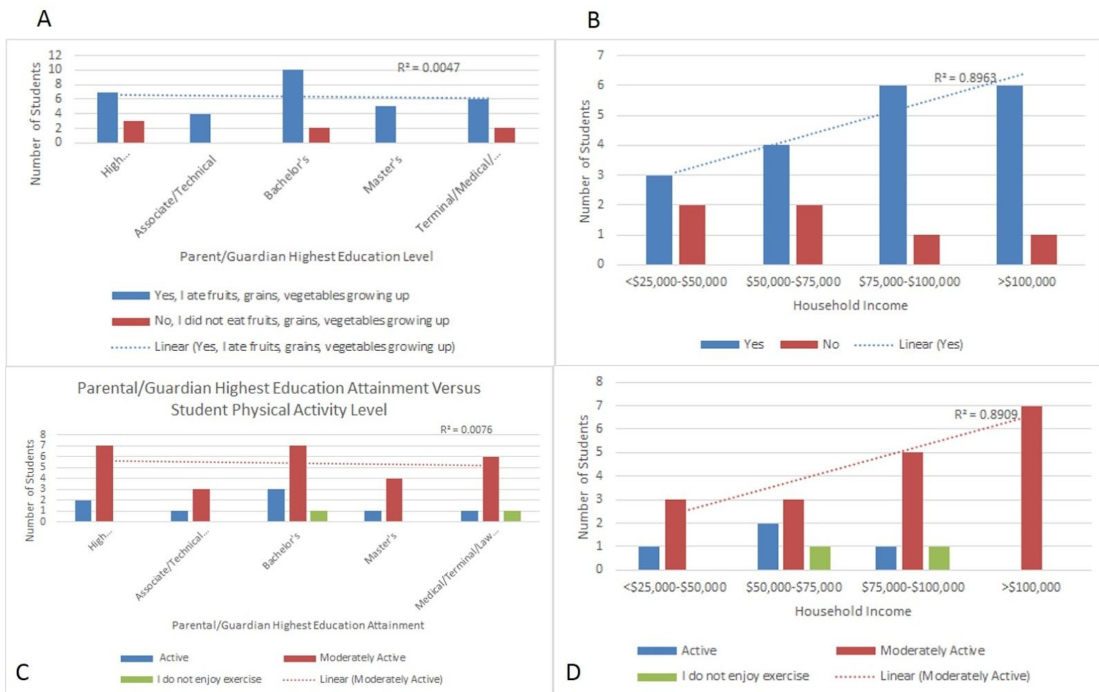

Figure 2. Relationship between highest education, household income, and health behaviors
A: Comparing participant's parental/guardian highest education level to participant's grain, protein, fruits, and vegetable intake as a child. Bars represent number of students who did or did not eat fruits, grains, protein, and vegetables as children. The correlation is not significant (N=38). **B:** Comparing participant's household income to participant's grain, protein, fruits, and vegetable intake as a child. Bars represent number of students who did or did not eat fruits, grains, protein, and vegetables as children. Correlation between parental/guardian highest education level to participant's grain, protein, fruits, and vegetable intake as child is significant, (N=25, R^2=0.90, p<0.00001. **C:** Comparing participant's parental/guardian highest education level to participant's activity level in college. Bars represent number of students who are active, moderately active, or who do not enjoy exercise while in college. . The correlation is not significant (N=37). **D:** Comparing participant's household income to participant's physical activity level in college. Bars represent number of students who are active, moderately active, or who do not enjoy exercise while in college. Trendline significant correlation between activity and household income significance (N=24, R^2=0.891, p<0.00001).

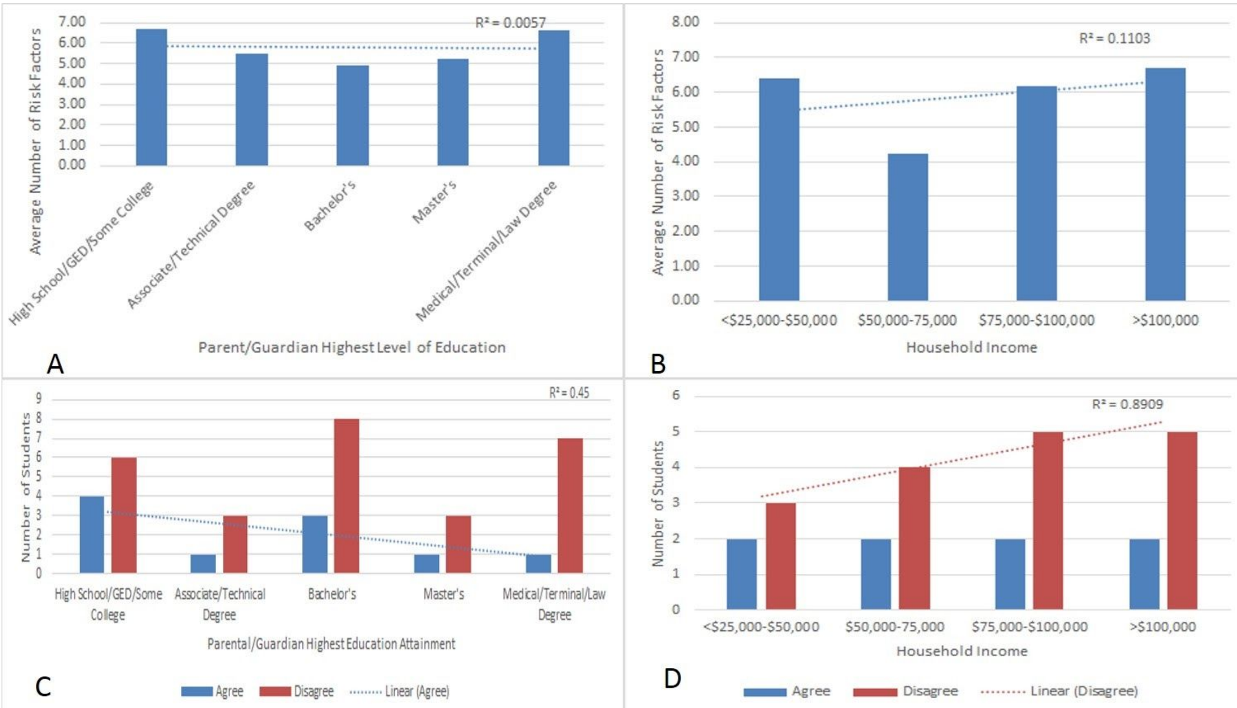

Figure 3. Relationship between highest education, household income and CVD risk awareness and attitudes. A: Comparing average number of risk factors of student's immediate and extended family members to parent/guardian highest level of education. Each bar represents the average number of risk factors of participant's immediate and extended family members. A number of 1-5.9 meant the average was 1 risk factor. A number of 6-6.9 means the average was 2 risk factors. A number of 7 means the average was 3 or more risk factors (N=33). The correlation is not significant. **B:** Comparing average number of risk factors of student's immediate and extended family members to household income. Ear bar represents the average number of risk factors of participant's immediate and extended family members (N=33). The correlation is not significant. **C:** Comparing awareness of risk of cardiovascular disease to student's parent/guardian highest education level. Responses are I agree I may be at risk of developing cardiovascular disease or I disagree, I may be at risk of developing cardiovascular disease. Bars represent the number of responses (agree or disagree) in each education group. Correlation between household income and awareness of developing cardiovascular disease is significant, (N=37, R^2= 0.45, p=0.0052). **D:** Comparing awareness of risk of developing cardiovascular disease to student's household income. Responses are I agree I may be at risk of developing cardiovascular disease or I disagree, I may be at risk of developing cardiovascular disease. Bars represent the number of responses (agree or disagree) in each income bracket. There is a direct correlation between household income and awareness of developing cardiovascular disease is significant (N=25, R^2 = 0.891, p< 0.0001).

RASM Study Results and Figures

Impaired mitochondrial dynamics and the hormone resistin, which is a hormone secreted from adipocytes, both have been shown to correlate with vascular disease [8]. The purpose of this study is to determine the effect of resistin on expression of mitochondrial dynamics protein machinery. Through a dose response study using rat aortic smooth muscle cells (RASM) it was demonstrated that resistin stimulation does not alter expression of mitochondrial fission protein Drp1 in RASM (**Figure 4A**). Resistin stimulation does not alter expression of mitochondrial fusion protein Opa1 in RASM (**Figure 4B**). Resistin stimulation does not alter expression of mitochondrial fission protein Fis1 in RASM (**Figure 4C**). Resistin stimulation decreases expression of mitochondrial fusion protein mfn2 by 32% in RASM (**Figure 4D**).

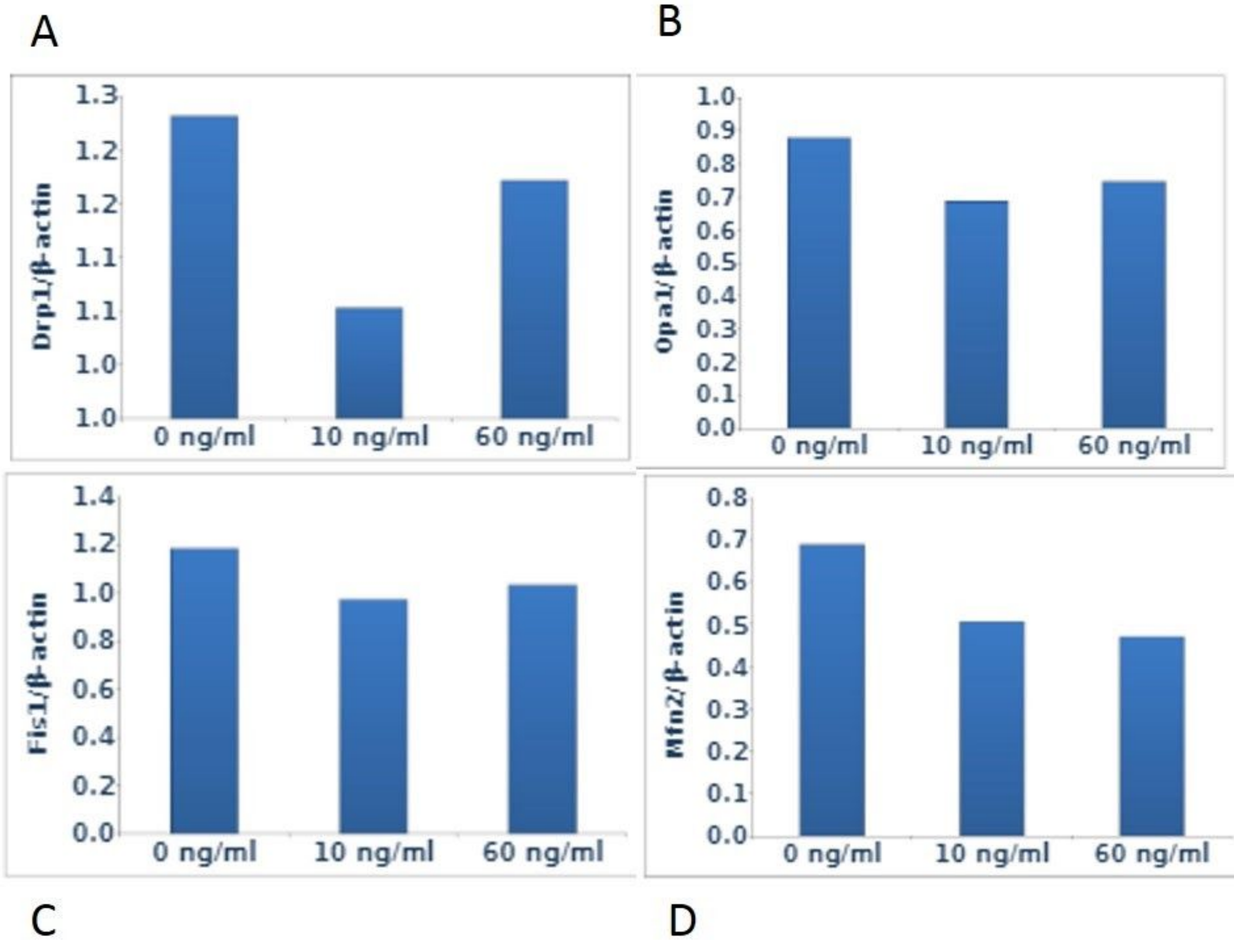

Figure 4. Effect of resistin on expression of the mitochondrial dynamics protein machinery. **A:** Resistin stimulation does not alter expression of mitochondrial fission protein Drp1 in RASM. **B:** Resistin stimulation does not alter expression of mitochondrial fusion protein Opa1 in RASM. **C:** Resistin stimulation does not alter expression of mitochondrial fission protein Fis1 in RASM. **D:** Resistin stimulation decreases expression of mitochondrial fusion protein mfn2 by 32% in RASM.

Discussion and Conclusions:

The student questionnaire data indicated that there is a correlation between socioeconomic status, specifically education, and maintaining healthy BMIs (**Figure 1A**). This data is consistent with existing data. Cutler et al found that people with higher education levels were least likely to be obese [14]. This may mean that people with more education are more knowledgeable about the benefits of a balanced diet and regular exercise. Other studies suggest that people with high education levels may be able to better interpret and apply nutritional and medical information [15]. It was hypothesized that income would present similar results as the highest education level compared to BMI, but there was no significance found in this study (**Figure 1B**). Existing data has shown that people with a higher income are least likely to be obese [16]. Our findings may be associated with the small N of 25. Many participants did not share their household income, so many points of data were missing.

Regular physical activity and a healthy diet both prevent the development of CVD and its risk factors [4], which is why the impact of SES on health behaviors was also measured. While education was a major predictor of BMI outcomes, income was a better predictor of health behavior. This suggests that affordability of resources, such as gym memberships and healthier foods, is a stronger indicator of making healthy choices rather than understanding the benefits of healthy choices. We asked students about their fruits, grains, vegetables, and protein intake as children because we reasoned that students may change their habits when they are on their own in college. Our data on eating protein, fruits, vegetables, and grains with every meal is consistent with existing data. Existing data concludes that diet quality significantly improves with higher household income [17]. Similarly, household income had a major impact on physical activity level in college (**Figure 2D**). Assuming that students have the same activity level prior to college, this finding suggests that students with a higher income may have had more opportunities to play organized sports or may have had a gym membership, so when they enter college, they keep these habits. Future studies would need to be conducted to compare the physical activity level of students before and during college to determine the impact of living on their own. Since this study is done in a college, everyone has equal access to a gym, so an extension of this study would need to be done to determine why income still affects activity level.

Participants were asked about their immediate and extended family health history. Neither highest education level of parent nor household income affected the average number of CVD risk factors of their family members. The average number of risk factors in the highest income bracket were the same in the lowest income bracket (**Figure 3B**). We hypothesize that cultural factors influence this finding, but another study would need to be conducted to understand why the average number of familial risk factors is high regardless of high education level and high household income. There is existing data on family communication about health among African American women and it is concluded that many people know discussing family health history is important, but researchers want to know more on how the conversation is conducted; there may be discussion differences between racial/ethnic groups [18] . It is possible that family members are in denial of their risk factors or do not know that because they have certain risk factors, their children are automatically at risk of developing the same risk factors. Another study would have to be conducted to determine the disconnect between one’s awareness of developing CVD and their own risks of developing CVD.

We also wanted to determine whether SES has an impact on student's awareness of developing CVD. We discovered that individuals with parents who have higher education levels and higher income were least likely to agree that they were at risk of developing CVD (**Figure 3C-3D**). This finding is interesting because the average BMI of the cohort is 26.72 +/- 7.69, meaning many students are in the overweight/obese range and obesity is a risk factor of CVD (**Table 1**). Furthermore, many students regardless of parent/guardian highest education level and household income have family members with at least two CVD risk factors and genetics are a non-modifiable risk factor of CVD. According to other data on awareness of cardiovascular health, it would be expected that individuals in the highest education and income brackets would recognize their risk because of access to educational resources that help them make preventative decisions [19]. We hypothesize that younger age may influence student's awareness; many young adults believe that they are invincible. However, this finding could also suggest that people really may not know the risk factors surrounding CVD, hence why mortality rates of CVD are so high in the United States.

The RASM study suggests that resistin stimulation decreases expression of mitochondrial fusion protein mfn2 by 32% in RASM. However, resistin stimulation did not affect expression of Drp1, Opa1, or Fis1.The data is from the average of three dose response studies and still no significant change was found in Drp1, Opa1, or Fis1 expression. Further dose response studies would have to be conducted to ensure that this finding is valid or if this finding is the result of technique error.

This finding suggests that resistin may stimulate mitochondrial fragmentation by decreasing expression of Mfn2. This is significant because current data has shown that an imbalance of mitochondrial fragmentation and fusion leads to vascular disease [8] and high levels of resistin are observed during obesity [20]. Understanding resistin's role in obesity and cardiovascular disease can give researchers a therapeutic target for the treatment of obesity-related cardiovascular diseases.

Findings from the questionnaire data and RASM study data suggests that CVD requires a multi-faceted conversation to help lower the CVD mortality rate in African American low-income communities. On the population level, social and economic power structures influence individual's health behavior, which impacts their risk of developing CVD. Furthermore, the questionnaire data revealed future implications of study regarding the cultural effect on Spelman student's health behavior, awareness, and attitudes towards cardiovascular disease and its risk factors. On the molecular level, more research needs to be conducted to understand the effect resistin has on the other fusion and fission proteins so different therapeutic targets become available for treating obesity-related cardiovascular diseases. Having a simultaneous population and molecular level conversation about cardiovascular health will hopefully lead to better cardiovascular health outcomes.

Acknowledgments

A special thank you to Dr. Anna Powolny Ventura, Senior Lecturer in the Biology Department, Dr. Mark Maloney, Biology Department Chair, and Dr. Tarshia Stanley, Ethel Waddell Githii Honors Program Director for support of this work.

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