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Influence Of Built Environment On Physical Activity Outcomes Among African Americans In Community-Based Obesity Intervention Studies

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INFLUENCE OF BUILT ENVIRONMENT ON PHYSICAL ACTIVITY OUTCOMES AMONG AFRICAN AMERICANS IN COMMUNITY-BASED OBESITY INTERVENTION STUDIES

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DEDICATION

For Mark, Brad, Bryan, Brittani and the late Donna Thomas who continue to support me in my academic endeavors wherever they lead me. Also, for my friends near and far and classmates in the Epidemiology 2014 cohort who have inspired me and encouraged me to finish this work.

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ABSTRACT

More than sixty-five percent of people in the U.S. are considered overweight or obese. African-Americans in the U.S. have a higher risk of obesity than any other racial group. One way to reduce this statistic is physical activity. Recreational green spaces (parks) can serve as an avenue to complete the 150 min/wk of recommended physical activity for adults by the ACSM. Data from SISTAS and HEALS interventions, that recruited overweight/obese African-Americans from Columbia and Florence, SC, was used to assess the association of recreational green space (parks) around a residence and physical activity. Physical activity measures of RAPA questionnaire (self-report), SenseWear® armband data (objective), and objective inflammatory biomarkers of interleukin-6 (IL-6) and C-Reactive protein (CRP) were utilized. Few, statistically significant, inverse associations were seen between amount of parks around a residence and physical activity for both the RAPA questionnaire and energy expenditure, evaluated by armband data. Positive associations were observed for inflammatory biomarkers at 0.75 (CRP: OR= 2.72; IL-6: OR= 2.532) and 5.0 (CRP: OR=1.811; IL-6: OR= 1.913) mile buffer regions for participant neighborhoods. No linear trends were observed with different buffer regions and more/less physical activity in any measurement. More research is needed to decipher the association that recreational green space (parks) have on physical activity in adult neighborhoods.

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CHAPTER 1

INTRODUCTION

1.1 Statement of the problem

Obesity is a national epidemic that has plagued the U.S. for multiple decades. Between 1976-1980 and 2007-2008, NHANES data has reported the prevalence of obesity to have more than doubled for adults aged 20-74(Cynthia L Ogden & Carroll, 2010). More than sixty-five percent of people in the U.S. are considered overweight or obese (Flegal et al., 2012; Center for Disease Control and Prevention, 2012). These individuals run a higher risk for diabetes, cancer, and cardiovascular disease among other ailments (Font-Burgada, Sun, & Karin, 2016; N. I. o. Health, 2012; Lavie, Parto, & Archer, 2016). With our nation growing heavier, the determinants of this weight crisis are important to consider as well as the individuals it affects most.

According to data from the 2011 National Health and Nutrition Examination Survey, African-Americans in the U.S. have a higher risk of obesity than any other racial group(N. C. f. H. S. Centers for Disease Control and Prevention, 2011-2012; Wang & Beydoun, 2007). Non-Hispanic blacks have the highest age-adjusted rates of obesity at 47.8%(C. L. Ogden, Carroll, Kit, & Flegal, 2014), making this group more susceptible to the long-term effects of excessive weight. Time has also been an influential factor in survival of those that are obese. It has been shown that as a person ages, their risk of death from obesity-related mortality increases(Masters, Powers, & Link, 2013). Therefore the importance paid to a person's weight loss and/or gain is crucial. Some of the leading risk factors for obesity are poor diet and insufficient physical activity(H. T. H. C. S. o. P. Health), both modifiable aspects of lifestyle.

Physical inactivity has become an alarming problem in the United States. As BMI increases so do the expenses of medical claims and healthcare costs (The Robert Wood Johnson Foundation, 2005). Specifically, suffering from obesity amounts to an estimated $147-210 billion per year of medical costs (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Since 2001 the American College of Sports Medicine has recommended the amount of aerobic activity for an adult as 150 min/week (Donnelly et al., 2009; Haskell et al., 2007; Jakicic et al., 2001).In South Carolina, less than half of adults engage in the recommended amounts of physical activity and over 25% admit to not exercising at all in the past month, which sits below the national average (N. C. f. C. D. P. a. H. P. Centers for Disease Control and Prevention, Division of Population Health, 2014; Mokdad, Ford, Bowman, & et al., 2003; Centers for Disease Control and Prevention, 2008, 2014b).

One of the Healthy People 2020 objectives emphasizes the importance of the built environment and physical activity through legislation. Specifically, the objective states, "developing community-scale policies for the enhancement of access to the built environment and physical activity opportunities (Promotion, 2008)". In order to develop these policies, research must be done into the built environment and how it is currently being used. The built environment, as Handy et al. defines it is a multidimensional concept. It normally focuses on neighborhood or regional measures. Dimensions of the built environment include density and intensity, land use mix, street connectivity, street scale, aesthetic qualities, and regional structures(Handy, Boarnet, Ewing, & Killingsworth). Analyzing these different dimensions can shed light on the way neighborhoods are set up for the people who live in them. Physical activity has been hypothesized as a crucial mechanism in which built environments can affect chronic diseases such as obesity (Frank, Engelke, & Schmid, 2003; Frumkin, Frank, & Jackson, 2004; Papas et al., 2007). Improving access to and availability of physical activity opportunities empowers individuals towards healthier lifestyles when in growing communities. However, availability of recreational green space without encouragement of exercise is insufficient to make an impact.

Local neighborhood initiatives specific to the populations they effect can be critical to prolonged change. Interventions tailored to high-risk populations have shown to reduce the amount of obesity and in turn adverse health outcomes such as cardiovascular disease and type II diabetes (Crane, Lutes, Ward, Bowling, & Tate, 2015; Douketis, Macie, Thabane, & Williamson, 2005; "Multiple risk factor intervention trial: Risk factor changes and mortality results," 1982). Built environments, if designed with evidence-based practices in mind, can help to entice inhabitants towards lives of physical fitness (Handy et al.). It has been shown that in most cases the availability and proximity to recreation facilities is associated with greater physical activity (Roux et al., 2007; James F.

Sallis, Floyd, Rodríguez, & Saelens, 2012; Troped et al., 2001; Wilson, Kirtland, Ainsworth, & Addy, 2004).

1.2 Significance

The Centers for Disease and Control and Prevention specify that 1 in every 4 deaths is from heart disease(N. C. f. H. S. Centers for Disease Control and Prevention, 2015). One of the leading contributions to heart disease is obesity, which can result from the lack of physical activity. It is recommended that adults obtain 30 minutes of moderate-intensity aerobic activity five times per week(Centers for Disease Control and Prevention). Despite this recommendation, many Americans do not meet this standard. More alarming is that under 20% of non-Hispanic blacks meet the U.S. Office of Disease Prevention and Health Promotion's 2008 Physical Activity guidelines (Centers for Disease Control and Prevention, 2008).

The "stroke belt" or the Southern states of Alabama, Arkansas, Georgia, Louisiana, Mississippi, North Carolina, South Carolina and Tennessee, have a higher rate of physical inactivity more than any other location in the U.S.(Centers for Disease Control and Prevention, 2008). Factors ranging from unique location aesthetics to dietary norms can combine to produce this concerning observation. Environmental factors including lack of parks, sidewalks and sports/recreation facilities can be identified as potential causes for inactivity(Organization). Density of parks in the neighborhood setting can shed light on physical activity opportunities. Through this study more can be learned for optimal built environment planning in the future.

Physical activity interventions can be an important avenue for counteracting substantial weight gain. The American College of Sports Medicine reports that numerous studies have validated that prolonged moderate-intensity PA of ≥150 min/wk helps to prevent weight gain and can induce loss when combined with energy intake moderation(Donnelly et al., 2009).Longitudinal analysis of this component can add to the minimal breadth of knowledge about the interaction of exercise interventions and built environment.

This study uniquely looks at individuals in a diet and lifestyle intervention, which aims to help reduce the burden of their overweight or obese status, to identify those characteristics in their built environment that influence their exercise regimen. These specific cohorts (SISTAS and HEALS) of African-Americans have not been specifically researched on their basis of recreational green space (parks). Additionally, the assessment of physical activity via inflammation biomarkers (IL-6 and CRP) in this population has not been done and scarcely reported as a measurement of physical activity. Furthermore the comprehensive mapping of Florence and Columbia, SC area parks and recreational facilities has not been done for this population and area and may give insight into city, state and county planning when designing living areas most suitable for recreational opportunity. Through this work, the built environment of parks around a person can be considered for influence on physical activity outcomes. Concurrently, this study is able to look at the possible association that diet and intervention class participants, who are already overweight/obese, may have with their surrounding recreational opportunities at baseline.

Ensuring that ample opportunities for recreational physical activity in neighborhoods exist in South Carolina is critical to reducing the burden of obesity on its people. However, there has been inconsistent data on whether or not the simple availability of recreational facilities or a specific component of the built environment promotes more physical activity (Ding, Sallis, Kerr, Lee, & Rosenberg, 2011; Feng, Glass, Curriero, Stewart, & Schwartz, 2010). Table 1.1 illustrates the inconsistent results that have been found between the built environment (specifically parks and recreational facilities) and measures of physical activity among adults.

This study implores similar study designs and techniques for analysis that have been done previously in order to add to the breadth of knowledge on this association. In addition, it explores this association with a specific population of overweight/obese African-American individuals enrolled in a diet and physical activity intervention program conducted in South Carolina.

1.3 Specific Aims

Physical activity is a recognized key component of health. Environments that support physical activity provide opportunities for the people that live in them to lead healthier lives. In the past there has been inconsistent data on defining what an ideal environment for the promotion of physical activity. Very little conclusive evidence has been published on how the built environment (specifically parks) affects physical activity of overweight/obese individuals, less so for populations of African-Americans. A retrospective, cross-sectional analysis, this thesis aims to decipher:

1. The makeup of African American participants in the SISTAS and HEALS interventions based on their residential locations and landscape of recreational opportunities available to them.

Hypothesis: The population of African-Americans that are being analyzed will have poor health characteristics (weight, BMI, fat percent, IL-6, and CRP values) and access to recreational facilities in their neighborhoods.

2. If the buffer region of recreational green spaces has an association with physical activity outcomes in an overweight African American population based on their self-report Rapid Assessment of Physical Activity [RAPA] questionnaire(Topolski et al., 2006)).

Hypothesis: The lower the amount of recreational green space opportunities available in an area, the less physically active the participants will be.

3. If buffer region of recreational green spaces has an association with physical activity outcomes in an overweight African American population based on their objective measures (inflammation biomarkers of CRP and IL-6 via blood samples; concurrently armband PA data for a subset of HEALS participants via energy expenditure)

Hypothesis: The lower the amount of recreational green space opportunities available in an area, the higher inflammation values will be observed for both

CRP and IL-6. Additionally, we hypothesize that the higher amount of recreational green space opportunities, the higher values of energy expenditure.

Table 1.1 - Summary Table of Selected[1] Studies Investigating the Built Environment/Parks and Measures of Physical Activity in Adults

Study Design	Lead Author	Year of Published	Location & Subjects	Physical Activity Assessment	Built Environment Measurement	Results[2]
Cross-sectional	Carlson et al. (Carlson et al., 2012)	2012	Baltimore and Seattle-Kings County ; Seniors, average age of 74.4 (n =719)	Average minutes of MVPA per week based on ActiGraph accelerometer recordings	Objective density (# of parks within 500 m buffer of home) dichotomized into none versus some.	Non-significant; interactions related to walking for leisure tended to involve walking infrastructure (interactions involving access to parks and recreation facilities and neighborhood aesthetics displayed a trend for significance)
Cross-sectional	Cohen, DA. (Deborah A. Cohen et al.)	2016, in press	United States cities; 174 parks	SOPARC (System of Observing Play and Recreation in Communities) Validated Observation Tool	List of public parks was retrieved, either supplied directly by the city's Department of Recreation and Parks or from their website	Average neighborhood park of 8.8 acres averaged 20 users/hour or an estimated 1,533 person hours of weekly use. Walking loops and gymnasia each generated 221 hours/week of moderate to vigorous physical activity
Cross-sectional	Fisher KJ (Fisher, Li, Michael, & Cleveland, 2004)	2004	Portland, OR; 582 survey respondents (182 men, 400 women) at random from 56 neighborhoods	Survey question responses: three items assessed neighborhood walking activity, reflecting levels of physical activity predominantly involving walking ; mean	Facilities for walking (trails, paths, parks) per neighborhood acre	Neighborhoods having greater proportions of low-income house-holds (<$15,000), more senior residents, more facilities for walking (trails, paths, parks) per neighborhood acre, and higher proportions of White residents were

				neighborhood walking-activity score (consistency and reliability checked)		associated with higher levels of neighborhood walking activity.
Cross-sectional	Hall and McAuley (Hall & McAuley, 2010)	2010	Convenience sample; Older women, average age of 69.9 (n = 128)	>10,000 steps/day vs. ≤10,000 steps/day based on Actigraph accelerometer recordings	Density and proximity: Presence and number of parks within 1 km of home (GIS)	Non-significant; Number of parks within 1 km of residence was not significantly different for those who had >10,000 steps/day vs. ≤10,000 steps/day (p = 0.15)
Cross-sectional	Jilcott et al.(Jilcott, Evenson, Laraia, & Ammerman, 2007)	2007	North Carolina; Women, average age 53 years (n = 199)	Average MVPA minutes per day based on Actigraph accelerometer recordings	Proximity: Both objective (GIS -1 and 2 miles from home) and perceived distance to closest park	Non-significant; In all models, the number of resources in the buffer was inversely related to MVPA, against the expectation that a greater number of facilities would be associated with more activity; There was no association between distance to resources identified through qualitative interviews and MVPA minutes, adjusting for age and BMI (standardized parameter estimate for GIS network distance = 0.06, P = .45)
Ecological	Kim, J. (Kim, Lee, & Lee,	2016	Korea; 204,324 adults from the 2012 Korean	MVPA from International Physical Activity Questionnaire	Community built environment, including areas of open space for PA, number of PA	Positive association; Residents in cities (OR = 0.75, 95% CI 0.60-0.93) and districts (OR = 0.70,

	2016)		Community Health Survey (KCHS)	(IPAQ)	facilities and amount of PA equipment, was linked with information from the 2012 KCHS based on residential location: counties, cities or districts. Areas of open space for PA included sports grounds, waterfront parks, village vacant lots, trails and parks.	95% CI 0.52-0.94) were less likely to engage in MVPA than residents in counties. While residents in communities with the least amount of physical equipment were less likely to participate in MVPA (OR = 0.72, 95% CI 0.57-0.90), residents in communities with the second smallest area of open space for PA were more likely to be active (OR = 1.37, 95% CI 1.07-1.77). The effect of built environment on MVPA was significant but relatively weak in comparison to the influence of individual correlates.
Cross-sectional (baseline data used from WOMAN)	King et al.(W. C. King et al., 2005)	2005	Pennsylvania; Overweight Caucasian and African -American postmenopausal women, average age 57 years (n = 158)	Average number of steps per day based on Yamax DigiWalker pedometer	Proximity: A park within "walking distance of home" (measured by GIS) "Walking distance" = 1500m	Non-significant; d living within walking distance (1500 m) of specific types of businesses and facilities were positively associated with individuals' physical activity level measured by pedometer ($p < 0.05$), parks was not specifically associated with mean steps per day ($p = 0.9200$)
Cross-sectional	Mc Conville, Master's	2009	Montgomery County; Adults, average	Walking for transport for less than 150 min/week	Density: number of parks within¼mile and½mile	Positive association

	paper		age 50 years (n = 251)	or 150 min/week versus not walking for transport, based on Actigraph accelerometer recordings	buffer; Proximity: miles to nearest park	
Cohort	Michael YL(Michael, Perdue, Orwoll, Stefanick, & Marshall, 2010)	2010	Portland, OR; 5995 community-dwelling men ≥ 65 years from the Osteoporotic Fractures in Men Study (MrOS)	Participants reported time walked per day at baseline (2000–2002) and follow-up.	Distance to a walking or hiking trail that was not part of a park was quantified in Cartesian measurements (straight-line), and distance to a park was quantified in network distance (distance needed to travel to reach the park destination); grouped park and trail distances into one eighth, one quarter, and one half mile categories; only one eighth and one quarter mile distances were used for parks	Proximity to parks and proximity to trails, respectively, were associated with a 22% (95% confidence interval [CI] = 1.01, 1.47) and 34% (95% CI = 1.16, 1.55) higher likelihood of maintaining or increasing walking time in high-SES neighborhoods, but there was no association in low-SES neighborhoods.
Cross-sectional	Saelens, BE. (Saelens et al., 2012)	2012	Seattle and Baltimore; Adults age 20-64 (n=2121)	Average minutes of MVPA (accelerometer recordings)	Self-report perception of neighborhood environment from Neighborhood Environment Walkability Survey (NEWS)	Non-significant ; Higher residential density, retail FAR, land use mix, and number of proximal private recreation facilities and parks were significantly related to MVPA, with higher intersection density marginally related to

						MVPA ; park proximity metrics were unrelated to overall physical activity and walking
Cross-sectional	Sallis, J.(J. F. Sallis et al., 1990)	1990	San Diego, CA; (n=2,053)	7-page questionnaire ; Classified into ‘sedentary’ and ‘exercisers’	Proximity of facilities to subjects by calculating the actual density of facilities within varying distances(1km and 2km) of subjects' homes	Positive association; Density of total facilities within 1km between sedentary and exerciser groups (P <0.05). At all distances (1-5km), density of pay exercise facilities significantly associated with exercise habits (P < 0.05 to P < 0.01).
Cohort	Salvo, D.(Salvo et al., 2014)	2014	Cuernavaca, Mexico; 677 adults	Participants wore Actigraph GT3X accelerometers for 7 days	Geographic information systems (GIS) to generate 500-m- and 1-km-buffer–based measures of net residential density, proportion of commercial land use, land-use mix, connectivity, walkability, and number of parks and transit routes ; obtained data on distance to the nearest park with GIS	Non-significant; participants who had 1 park intersecting the 500-m buffer engaged in 27.9 (14.9) fewer minutes per week of total MVPA (p= .05) and 16.8 (8.2) fewer minutes of MVPA within bouts (p = .03) than participants with no parks intersecting the 500-m buffer; no significant association for participants with 2 or more intersecting parks for total MVPA or MVPA within bouts (using 0 parks as reference), and no significant linear trends were found for this relationship.
Cross-	Strath et	2012	Wisconsin;	Average minutes of	Objective density:	Non-significant;

sectional	al.(Strath et al., 2012)		Older adults, mean age 64.3 (n = 148)	MVPA, based on Actigraph accelerometer recordings	Number of parks within 200 m of home, based on audit Objective proximity: at least 1 park within 200 m of home Perceived environment also recorded	Overall, recreational facilities (parks) were not significantly associated with total volume of PA (p = 0.114), light intensity PA (p =0.174), or moderate to vigorous PA (p = 0.925); count of facilities within 200m of home were not significantly associated with overall, light, and moderate to vigorous PA (p-values > 0.05)
Cohort	Van Cauwenberg, J.(Van Cauwenberg et al., 2015)	2015	Australia; 2700 Adults ranging from 57-67 years	Self-reported data on demographics, functional limitations, recreational walking and other recreational moderate- to vigorous-intensity physical activity (MVPA)	Self-reported on park proximity and park quality; objective information on area of residence was collected	The logit model showed perceived park proximity was significantly negatively related to the odds of non-participation in recreational walking -relationship significantly moderated by retirement status (OR interaction effect = 1.22; 95% CI = 1.05, 1.43). In non-retired participants, a one-unit increase in park proximity was related to 14% lower odds of non-participation in recreational walking (OR = 0.86; 95% CI = 0.79, 0.94). No significant relationships or moderating effects were found for park proximity and quality with other recreational MVPA in the logit or negative binomial part of the model.

Cross-sectional , ecological	Ying, Z.(Ying, Ning, & Xin, 2015)	2015	Shanghai, China; Residents aged 46 to 80 (n= 1100)	Total steps of walking were measured as a physical activity level ,total physical activity level in April–October 2010 was measured objectively with the Omron HJ-720ITC Pedometer (OMRON Inc., China)	Land-use mix, net residential density, street connectivity, environment variables such as proximity of river, parkland, and square ; utilized a 500m network buffer size around a household	Parkland and square proximity have a significant relationship with physical activity (P = .0270, .0010), BMI (P = .0260, .0130), and overweight/obesity (P = .0020, .0470). Land-use mix was positively associated with physical activity (P < .01) and inversely associated with BMI (P = .0240) and overweight/obesity (P = .0440). Green and open spaces were positively related with BMI (P < .01) and health status (P < .01).

[1]Selected studies were based on assessment of 'parks' or 'recreational facilities' as built environment measurements.
[2]Only results reported reflect pertinence to park proximity assessment; additional results omitted from table.

CHAPTER 2

LITERATURE REVIEW

2.1 Obesity and South Carolina

South Carolina has the 10th highest adult obesity rate in the United States (Foundation, 2015a). Adults aged 26-64 have over a one-third chance of being obese (Foundation, 2015a). Physical inactivity is the not the only determinant of obesity, but does contribute to it. Low levels of physical activity are a determinant for various ailments other than obesity such as cancer and heart disease. It's projected that both cancer and heart disease cases will increase two and three-fold respectively by 2030 (Foundation, 2015a).

Disparities in health mediated by race and socioeconomic status exist. The highest obesity rates in South Carolina are seen among the black population, who compose 27.8% of the total population in South Carolina (Bureau, 2014; Foundation, 2015a). In comparison to the adult average in the nation, individuals identifying as 'Black' have a 7% higher rate of being overweight or obese(Centers for Disease Control and Prevention, 2014a). Societal status also plays a role in disease risk factors. It has also been shown that the individuals with lower income and educational status are associated with increased likelihood of obesity (Foundation, 2011).

Obesity itself is manifested in the fundamental mechanism of energy balance. Not only energy expenditure, but genes and appetite can play a larger role in this process(Trayhurn, 2005). From when food, the energy source, enters the body the manipulation and breakdown differs intrinsically by individual. When excessive energy intake occurs the white adipose tissue can accumulate as fatty stores and put extra stress on functioning organs.

When an individual is obese they are at an increased risk of heart disease, stroke diabetes, cancer, and a number of other life-altering ailments(National Heart, 2013; Panel, 1998). A number of long-term longitudinal studies have shown obesity to independently predict coronary atherosclerosis (Garrison & Castelli, 1985; J. E. Manson et al., 1995; Rabkin, Mathewson, & Hsu, 1977). Changes that occur in lipid profiles from weight gain influence the functionality of organs, specifically the heart. Overweight and obese individuals have a much higher risk of morbidity and mortality from cardiovascular disease and a reduced life expectancy (JoAnn E Manson et al., 1990; Poirier et al., 2006). Therefore, it is crucial that measures are taken to reduce obesity in the U.S in order to alleviate burden on the heart and its function.

The biologic mechanism by which obesity works has been shown to increase the risk of cancer in individuals. With a variety of cancers, it's unfathomable that one pathway would exist for excessive weight to work through. Three developed hypotheses link obesity and cancer; insulin and insulin-like growth factors, sex hormones, and adipokines (Roberts, Dive, & Renehan, 2010). In one example, insulin production and utilization can be at the forefront in causing cancer. Insulin and insulin-like growth factors (IGFs) can be indicative of obese individuals because of their resistance to it, thereby preventing nutrient breakdown and promoting IGFs to inhibit binding, creating more opportunity for tumor development (Roberts et al., 2010).Obesity is tightly linked to increased risk of cancer in the esophagus, pancreas, colon and rectum, breast (after menopause), endometrium (lining of uterus), kidney, thyroid, and gallbladder(Institute, 2012). These cancer diagnoses can inhibit the already deteriorating quality of life that an overweight or obese individual experiences.

Emerging literature has shown that psychological illnesses are influenced by obesity. Excessive amounts of weight gain have shown to have effects on clinical depression, anxiety and other mental illnesses (Kasen, Cohen, Chen, & Must, 2007; Luppino, de Wit, Bouvy, & et al., 2010). Despite all the negative consequences of obesity, the NIH reported in 1998 it was the second leading cause of preventable death in the U.S.(Panel, 1998). However, the gap is closing and may have surpassed the number one spot of tobacco use(Hennekens & Andreotti, 2013).

2.2 Physical Activity

Physical activity (PA) is any body movement that works your muscles and requires more energy than rest (National Institutes of Health : National Heart, 2012).There are four main types of PA including; aerobic, muscle-strengthening, bone-strengthening, and stretching (National Institutes of Health : National Heart, 2012). Adding these types of activities through sport, leisure, and training can reap added health benefits.

Current CDC recommendations stipulate that 150 minutes of aerobic activity and muscle-strengthening activities on two days of the week are sufficient for important health benefits in adults(Centers for Disease Control and Prevention). However, this has not always been the standard for PA recommendations for adults. The American College of Sports Medicine (ACSM) has long been the front-runner in producing reports to the public on health exercising recommendations. Evolution of the PA recommendations from the ACSM has been previously summarized from a paper by Blair et. Al. in 2004 and displayed as Table 2.1 below (Blair, LaMonte, & Nichaman, 2004). This recommendation has not significantly wavered since 2004 by ACSM. Increasing the physical activity duration has been shown to have favorable health effects. Considering this, it has been shown in several studies that including consistent PA in lifestyle can reduce your risk of coronary heart disease (CHD), diabetes and cancer (S. S. Cohen et al., 2013; Eheman et al., 2012; Geffken et al., 2001; Gill & Cooper, 2012; National Institutes of Health : National Heart, 2012; Nocon et al., 2008; Warburton, Nicol, & Bredin, 2006; Winzer, Whiteman, Reeves, & Paratz, 2011).

Overall there is much knowledge to surround the claim that physical activity has a linear relationship with improvements in health status(Warburton et al., 2006). Improved physical activity can therefore be a driving force in healthy aging and deterrence of negative health outcomes such as obesity.

2.3 Built Environment Influence on Physical Activity

The area surrounding a person can have an altered effect on the way in which a person lives. Neighborhoods can provide an avenue for activity to take place such as walking, hiking, running or biking.

The built environment can be divided into five interrelated dimensions; density and intensity of development, mix of land uses, connectivity of street network, scale of streets, and aesthetic qualities of a place (Handy et al.). Much of this information comes from varying entities at the county and city level.

Not only is the physical existence of these entities important, but the access to physical activity locations is also important. Numerous studies have showed that access to physical activity locations can have an influence on patterns and frequency of physical activity in adults (Brownson RC, 1998; Hovell MF, 1992; H. M. Sallis JF, Hofstetter CR, 1992; H. M. Sallis JF, Hofstetter CR, Faucher P, Elder JP, Blanchard J, Caspersen CJ, Powell KE, Christenson GM, 1989). More specifically, thedensity of facilities around the home has been associated with an increase/decrease of physical activity(J. F. Sallis et al., 1990). The importance of defining what a facility of exercise looks like and the perceived impression it gives to physical activity opportunities still needs to be further studied.

However, many studies have failed to identify the direct correlation between the built environment for physical activity and its use (Chaudhury, Campo, Michael, & Mahmood, 2016; J. F. Sallis et al., 1990). These null findings could be due to any number of issues surrounding study design, sample size, or measurement biases. Study designs such as the case-control study are unable to assess built environment influence prior to physical activity outcomes. Sample sizes in these studies may also be a problem to finding a significant result. If not enough participants are analyzed then the study can be underpowered. Certain biases can also be apparent in studies that show no correlation. Respondent bias of a subjective measure of physical activity being used causes influence of social desirability. Responses can differ by age, gender, SES, and numerous other factors. Understanding the association between the built environment and human behavior can help to encourage models in which people will be physically active(Handy et al.). In this way, acceptable models can be factored into urban/rural planning for the future. Table 1.1 provides the inconclusive nature of the literature that exists and the need for further research.

2.4 Distances to PA Opportunities; Neighborhoods

Neighborhood analyses of the built environment have become increasingly important in city/town planning in recent years. Access to and available opportunities of physical activity contribute to these various environments. In the past, frequency and density of certain attributes in an environment have been useful tools in capturing the accessibility of the indicated attribute(Van Meter et al., 2011). Nevertheless, the computation of what constitutes a neighborhood surrounding a household can be subject to variation.

One study of adolescents has identified that an easy walking distance is 15 minutes at about 3 miles per hour. This walking pace correlates to about 0.75 miles which has been used to measure a feasible distance to constitute a neighborhood in multiple investigations (Colabianchi et al., 2014; Colabianchi et al., 2007). Defining of neighborhoods and what constitutes proximal influence on physical activity behavioral patterns needs more research. No known "gold" standard for neighborhood influence has been validated and used regularly in these types of studies.

2.5 Self-report vs. Objective Measures

Self-report measures have been an easy avenue to acquire data in epidemiologic studies. The problem that arises is the validity of the self-report and whether more objective measurements are available. A review of internationally-conducted studies of adults found no clear trend in the association between these two ways to assess physical activity. Self-report was overestimated and underestimated in comparison with its objective measurement, yielding discrepancy of using self-report as a good measure of actual PA in a number of analyses (Celis-Morales et al., 2012; Prince et al., 2008; James F Sallis & Saelens, 2000). Some causes of this could be the types of self-report and objective measures used for the study and study design. Retrospective methods may be more difficult to ascertain an accurate account of PA as well as self-report may not be able to indicate smaller amounts of physical exertion. Self-report measures can also differ by intensity. Moderately-intense exercises or leisure activities have shown to be more difficult to account for in comparison to high-intensity PA for adults, resulting in misreport (James F Sallis & Saelens, 2000). This could be because of the tendency to misclassify intensity when self-reporting, often times overestimating the effort going into the physical activity (Duncan, Sydeman, Perri, Limacher, & Martin, 2001; Fan, Wen, & Kowaleski-Jones, 2014). The balance between ease of use and accuracy can be the central dilemma when deciding which type of measure to utilize. Both subjective and objective measures can be information but to what extent depends on context.

2.6 Biomarkers

Objective measures of physical activity are abundant with accelerometers, activity trackers, gym logs and many others. Unfortunately these objective measurement devices are not necessarily feasible for many studies and/or create an added burden to the participant. Although, clinics can take anthropometric measurements, this has no bearing on the measure capturing infrequent or consistent physical fitness. Blood samples that are analyzed via biomarkers are a way in which to assess the implications of inflammation and ultimately risk for CVD and other diseases(Ridker, 2007).

C-Reactive protein (CRP) is a widely accepted biomarker for the presence of chronic inflammation. Inflammation can be an indication of lower levels of physical activity and its related health outcomes. Chronic low-grade inflammation is a characteristic that has been found in those that have obesity or diabetes(Trayhurn, 2005). Normal ranges for CRP in adults are between 5 and 10 mg/L Studies analyzing physical activity and body weight have shown significant associations with CRP (mg/dL) (Abramson & Vaccarino, 2002; Geffken et al., 2001; Mora, Lee, Buring, & Ridker, 2006; Visser, Bouter, McQuillan, Wener, & Harris, 1999). It has been seen that as physical activity increases in a person's physical fitness, thereby inducing weight loss and reducing CRP and IL-6 levels(Adams et al., 2015; Trayhurn, 2005).

Interleukin-6 (IL-6) also works with CRP in the inflammation mechanism. Interleukins such as IL-6 stimulate the production of CRP (Erlinger, Platz, Rifai, & Helzlsouer, 2004). Because of this joint effect in the pathology of inflammation, the most complete information on chronic conditions can be echoed by analysis of each biomarker.

2.7 Armband Data and PA

As previously discussed, objective measures can provide unbiased results from participants in a study. One form of objective measurement, physical activity trackers that track participant physical activity behavior can provide insight into their energy expenditure, amount of light/moderate activity among other related factors.

It is well documented that Sensewear® armbands are validated for measuring physical activity in the form of energy expenditure (Reece, Barry, Fuller, & Caputo, 2015; Welk, McClain, Eisenmann, & Wickel, 2007). Additionally, despite their potential for discomfort and minor side effects, noncompliance with wear of this device is minimal(McNamara et al., 2016). In order for this device to provide reliable measures it has been recommended that at least 3 weekdays be utilized to provide reliable measures of energy expenditure, inactivity, light, moderate and total physical activity(Scheers, Philippaerts, & Lefevre, 2012). Previous studies have found the armbands to be useful in accurately and easily assessing movement for intervention studies (Almeida, Wasko, Jeong, Moore, & Piva, 2011; Barone Gibbs et al., 2016). The continuous wear of this device has also been shown to encourage and weight loss through increased activity and lifestyle change (Shuger et al., 2011).

2.8 Potential Confounders/Effect Modifiers

Education Level

Education and affluence have shown to have influence on physical activity behaviors. A number of studies have seen that with lower educational attainment there is an association with lower physical activity and higher incidence of obesity thereafter (Foundation, 2011; A. C. King et al., 2000). Additionally, of those in the lowest education and income categories only 10-14% met the PA guidelines, whereas the highest educated were 21-28% (S. S. Cohen et al., 2013). In contrast, one study observed that those with higher affluence and education were also among those who were living sedentary lifestyles active, potentially due to the specific population of Czech adults (Sigmundova et al., 2015). Conversely, the same study just described and another from an American population found that early, old-age adults that were lower educated individuals become less physically active over time (Shaw & Spokane, 2008; Sigmundova et al., 2015). Seemingly, education plays a role on physical activity; however the exact relationship seems to be uncertain from the literature and could be differentiated by additional population characteristics.

Socioeconomic Status (SES)

Socioeconomic status plays a crucial role in physical activity behaviors and associated health outcomes. It is already well established that health is affected by both socioeconomic status and physical activity(Mackenbach et al., 2008). SES is highly is highly associated with one's residential choices, which correlates with neighborhood crime levels, availability of recreational facilities, and other features of the built environment. In fact, one such study found that low-socioeconomic individuals were less likely to meet the CDC-ACSM recommendations for PA and were less satisfied with neighborhoods, crime, untrustworthy neighbors, among other reported factors(Wilson DK, 2004). Additionally, Wilson et al. measured availability of resources for exercise objectively in a rural, largely African American, Southeastern US population, and found it was the same across socioeconomic levels; conversely, perceptions of these available opportunities differed (Wilson DK, 2004). However, measurements and perceptions of PA opportunities may not be the same in other populations.

Another barrier to physical activity can be job status (a component of SES). Demands of a job have been shown to have a considerable effect on leisure-time physical activity. As job responsibility increases leisure-time physical activity declines (Fransson et al., 2012). Even among those who had physically-demanding jobs, a dose-response association could be seen when high-intensity PA in leisure-time reported indicated better working ability. Low and moderate-intensity PA during leisure-time failed to show this benefit among workers (Calatayud, Jakobsen, Sundstrup, Casaña, & Andersen, 2015). Among low-wage workers, the importance of PA promotion in the work environment encouraged healthy exercise habits (Nobrega et al., 2016; Strickland et al., 2015). Although the availability of resources for physical activity is numerous, time to be able to devote to outside activities or work environment might detract from being able to utilize those resources. For men it was found that high SES men did more leisure-time PA and low SES men completed more job-related and household PA; contrary women of high SES were more active in all PA activities (leisure-time, job-related, and household) than low SES women (Ford et al., 1991).

Availability of physical activity opportunities may not be the only barrier to exercise. Varying cultures within social classes may influence perception of opportunities. One study in Australia aimed to analyze the psychosocial aspect of cultures with PA choices and found the gradient it follows can be key to understanding the barriers of social class(Ball, Carver, Downing, Jackson, & O'Rourke, 2015). Directing policies to make neighborhoods with more 'walkable', increase available recreational facilities and improved crime rates could be beneficial. Ball et al. found that along with neighborhood walkability, improved crime rates and available recreational facilities were identified as part of key values of PA perceived culturally by each group of individuals (Ball et al., 2015).

Age

As a person ages, the possibility of negative health outcomes also increases. Physical activity can help reverse this trend, which is inversely related to age(James F Sallis, 2000; U.S. Department of Health and Human Services, 1996).Despite the health benefits of physical activity, about two thirds of adults still remain underactive(Stewart et al., 2001). Also, it has been reported by the CDC from BRFSS data that only between 28-34% of adults ages 65-74 are physically active(U. D. o. Health & Services, 2004). Some evidence has shown trends of declining vigorous physical activity as a person ages and an inclining slope of moderate intensity PA (James F Sallis, 2000). Increasing age has shown to correlate with the decline in strengthening and stretching(Caspersen, Pereira, & Curran, 2000). In this way, physical activity can be a burden to sustain as functionality decreases. Also, physical inactivity can exacerbate the already known decline in physical function due to age (Villareal, Apovian, Kushner, & Klein, 2005). The U.S. reported in 2012 having more than doubled the percentage of children as overweight or obese, which translated into the overweight and obese adult population over time(Foundation, 2015b).

Gender

Despite physical activity recommendations for men and women being the same, the ways and barriers to obtaining these goals are quite different. A study utilizing the 1992 National Health Interview Survey found that adult females were more physically inactive than their male counterparts(Azevedo et al.; Caspersen et al., 2000). Often women play a different role in the structure of a family which could contribute to time available to exercise freely. However, the role of the woman in the household could keep the decline of physical activity at a slower rate as seen in a review of human and animal aging(James F Sallis, 2000). Men have been found to participate in more moderate-intensity, vigorous-intensity and total leisure-time physical activity practice(Azevedo et al.). In this way gender norms could compromise the true effects of built environment (e.g., availability of recreational green space) on physical activity behaviors.

Table 2.1 – American College of Sports Medicine Recommendations of Adult Physical Activity over Time, 1975-2000.

Dose of aerobic physical activity recommended in the American College of Sports Medicine's *Guidelines for Graded Exercise Testing and Exercise Prescription*, 1975–2000[1]

Objective and year of edition	Activity		
	Frequency	Duration[2]	Intensity
	d/wk	*min/d*	*% HRR*
Cardiorespiratory fitness			
1975 (29)	3–5	20–45	70–90
1980 (30)	3–5	15–60	50–85
1986 (31)	3–5	15–60	50–85
1991 (32)	3–5	15–60	40–85
1995 (33)	3–5	20–60	40–85
Health promotion			
2000 (34)	7	≥20	40–85

- ↵1 HRR, heart rate recovery.
- ↵2 Continuous activity except for recommendation from reference 34, which was for cumulative totals, with a minimum of 10 min of activity per session.

This figure was originally published in a paper by Blair et al., 2004.(Blair et al., 2004)

CHAPTER 3

RESEARCH METHODS

3.1 Participants and Setting

Study Population

Data was pulled from both the HEALS and SISTAS study interventions. Both HEALS and SISTAS are comprised of overweight/obese (as classified by the BMI scale) African-Americans who resided in the state of South Carolina, primarily in but not exclusive of Lexington, Richland, Darlington, and Florence counties. Figure 3.1 below depicts the study protocol for the HEALS study. Additionally, Figure 3.2 depicts the study protocol for the SISTAS study. For analysis purposes, only 'Step 3' was utilized in this study analysis before interventions began.

The SISTAS and HEALS studies obtained BMI calculations from the baseline, first clinic visit after randomization, in which no intervention had been administered. Participant demographics and subjective physical activity levels will be obtained via the validated Rapid Assessment of Physical Activity(RAPA) questionnaire(Topolski et al., 2006) at baseline. The questionnaire was originally developed by Dillman(Dillman, 2000; Jenkins & Dillman, 1995) and has been determined to be a validated measure of physical activity in clinical practice for older adults, outperforming the Behavioral Risk Factor Surveillance System(BRFSS) and Patient-centered Assessment and Counseling for Exercise

(PACE) (Topolski et al., 2006). Blood samples and anthropometric measures were also taken on the date of the baseline clinic.

Clinics (baseline, 3- , and 12-months) were the contacts of study participants for each clinical trial. The baseline clinic was conducted before randomization into intervention or control groups in both studies. Phone calls to study participants were made to schedule time slots for attendance at clinics. Each clinic was inclusive of questionnaire data (self-report mailed before attendance) and anthropometric measures (e.g., height, weight, BMI, blood samples, etc.). Specifically in HEALS, objective physical activity and energy expenditure monitoring (via SenseWear® armband) were collected. For the SISTAS study, instruction for after clinic recall (24 hour recall for diet and physical activity) was also received at clinic visits. Trained professionals in phlebotomy conducted blood draws and trained study assistants measured waist-to-hip and height dimensions to the nearest centimeter.

The HEALS and SISTAS studies obtained BMI calculations from clinic visits via the bioelectrical impedance assessment using the Tanita TBF-300WA Body Composition Analyzer (Adams et al., 2015; Hébert et al., 2013). This BMI calculation was an inclusion criteria for both studies as only those with a BMI of ≥25 kg/m^2 (the cut point for overweight/obese classification outlines by the World Health Organization) were allowed to participate. Blood samples were taken to analyze for inflammatory or glycemic control markers. Plasma was aliquot from blood samples and stored until analyzation. C-reactive protein (CRP) and interleukin 6 (IL-6) were the specific markers analyzed. An enzyme-linked immunosorbent assay kit was used to measure plasma cytokine levels (Quantikine kits) for CRP and IL-6 (Hébert et al., 2013). Specific details for this are outlined in a previous paper by Hebert et al in 2013. Since multiple timepoints were collected, a study ID was assigned and utilized for identification for all samples collected. Those running the blood samples were blinded to which study IDs indicated intervention or delay intervention participants.

Armband data for HEALS participants was collected via Sensewear® software. Calibrations for each participant was done by age, date of birth, height and weight, current smoking habits, and dominant hand (Hébert et al., 2013). Only those who had ≥4 days of the possible 7-day request of usage were included in analysis.

Recreational green spaces were assessed from a comprehensive map collected from contributions of county, state, and city parks in the Columbia, SC and Florence, SC areas, in which participants resided. Park data was obtained from separate entities and merged together in one data layer. openstreetmap.org (the 'leisure and sport' layer), ArcGIS online (National forests, state parks, national parks), Columbia parks from City of Columbia GIS division, Florence parks from the City of Florence GIS division, SC Forestry Commission and SC Department of Parks, Recreation, and Tourism. Those green spaces that are identified as points will be transformed into polygons for analysis utilizing their given acreage in a calculation of a radii for their area (Columbia parks) or assigning an average land coverage for all parks without acreage given (Florence parks). Varying buffer regions (0.25, 0.50, 0.75, 1.0, 1.5, 3.0, and 5.0

miles in radius) surrounding participant geocoded addresses indicated the accessible environment for physical activity.

3.2 Study Design

This thesis project will utilize a retrospective, cross-sectional analysis from two community-based interventions. The diet and physical activity interventions of HEALS (Health Eating and Active Living in the Spirit) and SISTAS (Sistas Inspiring Sistas Through Activity and Support) was combined to create a group of participants with similar baseline characteristics (race, BMI, age range, etc.) and analogous intervention components (i.e., culturally-tailored classes). The details of the HEALS study have been previously outlined (Hébert et al., 2013). The SISTAS study, adapted from the same methodology as HEALS differs only in gender composition of participants and recruitment locations. SISTAS incorporates only women and did not rely upon churches as an avenue for obtaining potential participants or disseminating the intervention protocol.

The lifestyle intervention studies were comprised of 12-week classes tailored to overweight/obese African-American participants and their concerning barriers to lifestyle change within this demographic. Obese individuals were sought to be recruited in light of the potential implications in behavioral modification of this population for improved health.

Simple means and frequency procedures were run in order to describe the characteristics of the study population via gender distribution, BMI, employment status, age, etc. The amount of recreational green space for each participant, as defined by available designated parks and recreational opportunities (those within their buffer region), were analyzed through ArcGIS. Buffer regions of 0.25, 0.50, 0.75, 1.0, 1.5, 3.0, and 5.0 mile radii around participant's addresses were utilized for analysis. Multivariate regressions will be run with counts of recreational green spaces (among all buffer regions specified above) being the dependent variable in correlation to their subjective self-report physical activity and objective physical activity taken from IL-6 and CRP values indicating inflammation. An additional objective physical activity assessment for select HEALS participants was derived from armband data via energy expenditure extracted.

Original study protocols (SISTAS and HEALS) both received USC Institutional Review Board (IRB) approval. Current study analysis of these combined datasets is covered under original review.

3.3 Sample Size

Overweight/obese individuals will be utilized from the HEALS and SISTAS intervention studies and their addresses will be geocoded. Only those participants who completed the baseline clinic will be utilized as well as having all values completed for the identified confounding variables. For the full study analysis, SISTAS contributed 250 persons, while HEALS contributed 208, for a combined total of 458 persons included for Aims 1-3 after exclusionary criteria are met.

3.4 RAPA Questionnaire

The Rapid Assessment of Physical Activity instrument was developed from the Centers for Disease Control and Prevention guidelines for physical activity (i.e., 30 minutes or more of moderate physical activity on every day or most days of the week). It is a nine-item questionnaire based on yes or no questions to levels of physical activity ranging from sedentary to regularly vigorous. Strength training and flexibility is also assessed within this tool and given a score (Topolski et al., 2006).

3.5 Sensewear® Armband

Sensewear® armbands were provided to the participants in the HEALS intervention study. Energy expenditure, intensity of physical activity, and bouts of physical activity were monitored with this device. Measures of participant age, date of birth, height and weight, current smoking habits, and dominant hand were utilized for calibration via software provided by Sensewear®. Participants were asked to wear the armbands for 7 days while they were awake as well as report their hours of sleeping separately for calculation. Only those with ≥ 4 days of data were included. A day of use was determined by wearing the device and accounting for sleeping time for a minimum of 20 hours.(Hébert et al., 2013)

3.6 Data Analysis

Baseline characteristic analyses were completed by means and frequency procedures to understand the make-up of the study population. Assessment between the excluded participants and those in the full study were done with paired t-tests and chi-squared analysis to determine if statistical difference occurred ($p < 0.05$).

To assess if the amount of physical activity reported is related to the availability of parks in the neighborhood of the participants, a full model utilized a multinomial regression analysis when the outcome variable was continuous. Continuous outcomes assessed were inflammatory biomarkers and energy expenditure. Logistic regressions were used when the outcome variable was categorized or dichotomized. Individual univariable analyses were run for each independent variable and outcome. Independent variables assessed as continuous were age, BMI, and counts of recreational green spaces (parks) at 0.25, 0.50, 0.75, 1.0, 1.5, 3.0, and 5.0 mile from the participant's home. Categorical independent variables consisted of education, SES status (determined by employment status), gender, 'High'/'Low' CRP, 'High'/ 'Low' IL-6, and 'High'/'Moderate'/'Low' counts of parks. Buffer regions were defined with 0.25, 0.50, 0.75, 1.0, 1.50, 3.0 and 5.0 mile radius around each participant geocoded address based on self-reported data. The initial 0.75mi radius was determined from previous research on this topic, assessing a 15-minute walk around a residence which can be defined as a neighborhood (Pate et al., 2008). Smaller and larger radii were also analyzed to include the shorter distances that the study population may utilize for physical activity as well as conversely the places in which someone might drive. The addresses of the participants were obtained from self-report measures and geocoded in ArcGIS. Recreational space (parks) locations were acquired via government and publicly available entities in both point addresses and polygon data. Park addresses given as points were converted to polygons for analysis by 1) using acreage to construct a proper radius around the specified location or 2) utilizing ArcGIS to estimate average radii for all parks in that layer.

Self-reported RAPA scores assessed activity level for HEALS participants only as data was not available for the combined SISTAS and HEALS cohort. Comparisons of engaging in recommended amounts of physical activity and participating in more than the recommended amount of physical activity in reference to sedentary behavior was determined. The third aim addresses the amount of parks around a participants' residency to objective measures of physical activity. Clinical biomarkers for inflammation, IL-6 and CRP, are analyzed separately among all participants of SISTAS and HEALS combined. Another objectively measured physical activity outcome for HEALS participants (only) was 7-day, Sensewear® armband data. Overall energy expenditure was utilized from calculated values of awake and reported sleep activity.

In all circumstances an alpha level of 0.05 was utilized. Exclusion criteria for ArcGIS included residences that were reported invalid or as PO Boxes. The full amount of geocoded addresses of participants utilizing ArcGIS was n = 507. In addition, for the complete study population, those with missing data for any of the anthropometric and self-report measurements from the baseline clinic and included in the multivariate analysis excluded an additional 49 participants. Each intervention study contributed 250 and 208 participants from SISTAS and HEALS respectively, for a final study population of 458 participants. All data analyses were run on SAS 9.4 and/or with ArcGIS 10.2.2.

3.7 Variables

Aim 1 Outcome of Interest: Study population unique characteristics of combined cohort and distribution of population into relevant study measures

Frequency and means were calculated to explore the relationships between the built environment and the study participant characteristics (e.g., age, gender, height, weight, employment status, etc.). Frequency distributions for gender, education level, employment status, IL-6, and CRP were calculated and displayed. Means and standard deviations for continuous variables such as BMI, weight, height, age, fat percent, IL-6, CRP, parks in each buffer region (additive), and parks in each buffer region (non-additive) are also presented.

Aim 2 Outcome of Interest: PA of intervention participants

PA will be measured subjectively via self-report questionnaire (RAPA) for HEALS participants only. Pre-defined categories for the RAPA self-report questionnaire were analyzed on a scale of 0='sedentary' to 2='over recommended' PA. Final interpretation of physical activity is classified as

‘Sedentary’, ‘Meeting Recommended Physical Activity’, and ‘Over Recommended Physical Activity’. (Topolski et al., 2006).

Aim 2 Main Exposure: Amount of recreational green space

Counts of this exposure will be determined from the geocoded addresses of participants and the recreational green space coordinates (parks & designated areas of recreational opportunity). Buffer regions will be analyzed on a 0.25, 0.50, 0.75, 1.0, 1.5 mile radii around the participant address. Defined categorical counts of low, moderate, and high will be based on amount of recreational opportunity (counts of defined parks) within the defined radius. Methodology for categorical counts was determined separately for each buffer region. Interquartile ranges were utilized to define cutoff points for ‘Low’, ‘Moderate’, and ‘High’ definition (see Table 3.1). Table 3.2 designates the distribution of counts for each categorized region.

Aim 3 Outcome of Interest: PA of intervention participants

PA will be measured objectively. It will be measured via biomarkers of CRP and IL-6 from blood samples. This measurement will be a continuous variable with units of mg/L for CRP and pg/mL for IL-6. Analysis will further be run treating CRP and IL-6 as dichotomous outcomes. CRP will be dichotomized as high (≥3.0mg/L) and low (<3.0 mg/L) based on the risk assessment of cardiovascular disease by the CDC and AHA(Pearson, Mensah, Hong, & Smith, 2004). Similarly IL-6 will be dichotomized into high (≥ 2.0 pg/mL) and low (< 2.0

pg/mL) that utilizes the CRP distribution of the participants, as has been done in previous methodology(Cho, Kivimaki, Bower, & Irwin, 2013). Table 3.1 illustrates the dichotomized cutoff points. The median values of IL-6 in the ‘high’ and ‘low’ defined groups of CRP was used to find the appropriate IL-6 cutoff. An approximate of the average of the two medians was used as the cutoff point for IL-6 values.

An additional analysis of objective measurement of PA will be 7-day armband data done for HEALS participants only. Armband data, providing energy expenditure in kilocalories, will be run as a continuous variable in comparison to park counts (continuous and categorical).

Aim 3 Main Exposure: Amount of recreational green space

Counts of this exposure will be determined from the geocoded addresses of participants and the recreational green space coordinates (parks & designated areas of recreational opportunity). Buffer regions will be analyzed on a 0.25, 0.50, 0.75, 1.0, 1.5 mile radii around the participant address. Defined categorical counts of low, moderate, and high will be based on amount of recreational opportunity (counts of defined parks) within the defined radius. Methodology for categorical counts was determined separately for each buffer region. Interquartile ranges were utilized to help define cutoff points for ‘Low’, ‘Moderate’, and ‘High’ definition (see Table 3.2). Table 3.3 designates the distribution of counts for each categorized region.

3.8 Potential Confounders and Effect Modifiers

Confounders and effect modifiers, because of the imperfect design of this analysis may exist and have influence on the results. In an effort to reduce the manipulation of these variables the incorporation of their effect will be taken into account but is not exhaustive of all the possible influences. These are the potential confounders and effect modifiers used in this thesis:

- Age: This will be analyzed as a continuous variable with participants ranging from 29-87 years.
- Education level: Education will be a categorical variable divided into the following categories: '8th grade or less', 'more than 8th grade and less than high school', 'high school completed, no college', 'high school completed, some college', 'college completed', and 'more than college completed'. The highest education level of the participant will be used. The reference level that will be utilized for analysis is 'more than college completed'.
- Socioeconomic Status (SES): Socioeconomic status will be based on self-report at baseline. Those with 'full-time', 'part-time', 'retired', and 'unemployed' job status will make up the categorical variable of SES. The reference level that will be utilized for analysis is 'unemployed'.
- Gender: Males and females will be indicated and factored into multivariate analysis. The reference level that will be utilized for analysis is 'male'.

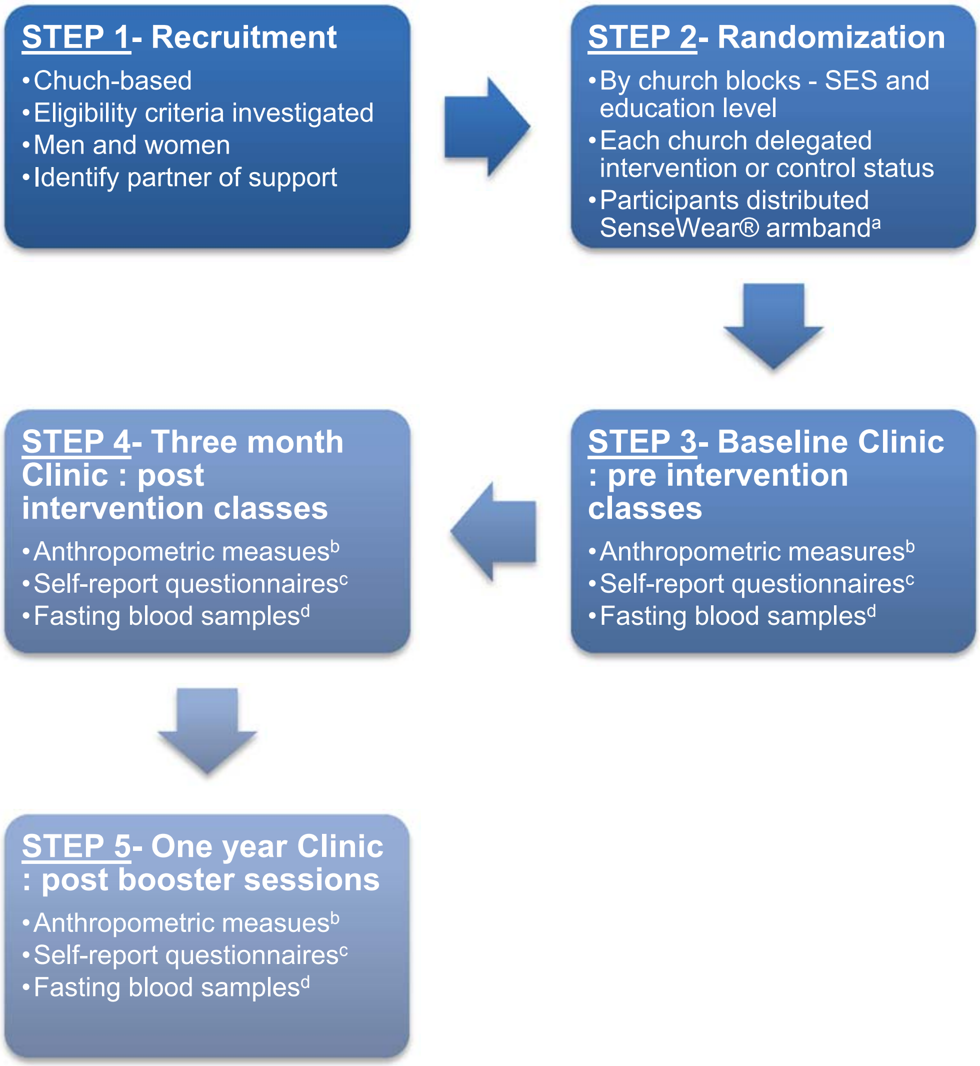

Figure 3.1 – HEALS Study Protocol

[a] Participants were provided monitors for physical activity and were calibrated by participant date of birth, height, weight, current smoking habits, and dominate hand. Only those with ≥ 4 days of data were included in analysis.

[b] Blood pressure, height, hip and waist circumferences, total body weight, and fat mass were obtained.

[c] Questionnaires of demographics, dietary intake (using a version of the National Cancer Institute food-frequency questionnaire modified for use in South Carolina), physical activity, depression, social support, and social desirability and approval were obtained.

[d] Blood samples were collected and analyzed for CRP and IL-6.

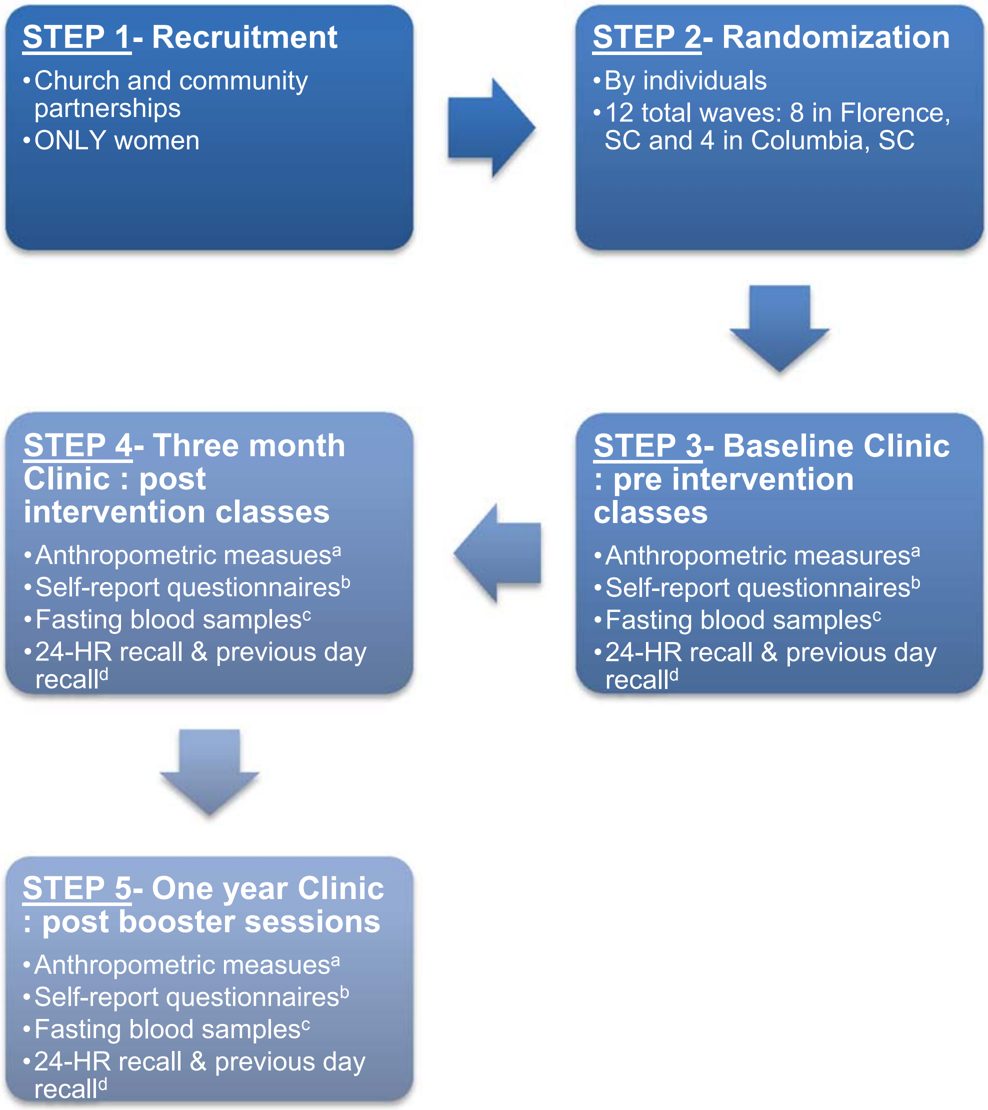

Figure 3.2 – SISTAS Study Protocol

[a] Blood pressure, height, hip and waist circumferences, total body weight, and percent body fat (including fat mass and fat free mass) were obtained.

[b] Questionnaires of demographics, Health & Lifestyle, Center for Epidemiologic Studies Depression Scale (CESD-10), Everyday Discrimination Scale, Perceived Stress Scale, Pittsburgh Sleep Quality Index, Self Efficacy for Diet, Self Efficacy for Exercise, Social Support, Social Support and Eating Habits/Exercise, the Health Care Systems distrust scale, and Racial Pride Scale (urban AA women) were obtained.

[c] Blood samples were collected and analyzed for CRP and IL-6.

[d] 24-HR recall was and interview used to assess dietary energy, nutrient and food group intakes within two-weeks post-clinic. The Nutrient Data System for Research software (NDSR®), licensed from the Nutrition Coordinating Center (NCC) at the University of Minnesota (Minneapolis, Minnesota), was utilized to conduct the dietary interviews. Previous day recall was used to collect information on physical activity and conducted by the same dietician who conducted the 24-HR recall.

Table 3.1 – Inflammation Biomarker Dichotomization

	CRP (mg/L)	IL-6 (pg/mL)
High	≥ 3.0[1]	< 3.0
Low	≥ 2.0	< 2.0

[1] High categorization for CRP was determined by CDC and AHA guidelines for higher risk of cardiovascular disease (Pearson et al., 2004).

Table 3.2 – Categorization of Buffer Region Counts

	Buffer Region (miles)[1]				
Quartiles	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Q1 25%	0	0	2	16	74
Q2 50%	1	3	10	58	162
Q3 75%	4	10	22	89	195
Cutoffs Utilized					
Low	0	< 3	≤ 2	< 16	< 74
Moderate	2 > x > 0	10 > x ≥ 3	2 < x < 22	16 ≤ x < 89	74 ≤ x< 195
High	≥ 2	>10	≥ 22	≥ 89	≥ 195

[1]Buffer regions not accounted for at 0.25 and 0.50mi. Distance in miles is indicative of radius length of buffer region.

Table 3.3 – Frequencies of participants in defined buffer region categories

	Buffer Regions[1] (miles)				
Categories	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Low	216	218	124	105	112
Moderate	33	111	216	232	229
High	209	129	118	121	117

[1]Buffer regions not accounted for at 0.25 and 0.50mi. Distance in miles is indicative of radius length of buffer region.

CHAPTER 4

RESULTS

Tables 4.1 and 4.2 – Descriptive Statistics

The final number of participants that were able to be geocoded in ArcGIS was n = 507. Data on self-reported demographics, baseline clinic measurements, and regional analysis in ArcGIS combined to display a comprehensive outlook of participants

Table 4.1

Of those that reported on gender, 90.18% identified as female. The most frequent educational attainment level was 'High school completed, some college' (37.60%) as well as employment at a full time job (50.31%). Average age of the participants was 53.4 years of age and average BMI was 36.33 kg/m^2, falling in the Class II obesity category. Considerably high average value for C-Reactive Protein (CRP) was observed for the population at 6.62mg/L. As buffer radius increased (0.25mi-5.0mi) the average number of parks (recreational green spaces) within the regions also increased.

Table 4.2

This table displays individuals who had completed data in all categories of number of parks (all count data- 0.25, 0.50, 0.75, 1.0, 1.5, 3.0, 5.0, 0-0.5, 0-0.75, 0-1.0, 0-1.5, 0-3.0, 0-5.0), BMI, fat percent, fat free mass, waist, hip, height, systolic blood pressure, diastolic blood pressure, waist-to-hip ratio, gender, education, employment, age, IL-6 and CRP. Averages and frequencies did not differ significantly from participants who were from further analysis from *Table 4.1*.

Table 4.3

Continuous and categorical variables used to describe the study population were compared before and after exclusion of incomplete data. 'Before' values can be found in *Table 4.1* and 'After' values in *Table 4.2*. Comparisons of continuous variables were analyzed with a t-test and categorical with chi-square/Fischer's exact test. No significant differences ($p < 0.05$) were seen between the excluded and included participants.

Table 4.4

Univariable analysis was run with each potential confounder/effect modifier and the objective measures of IL-6 and CRP. Gender (females) showed a significant positive association (p-value 0.0407) with CRP. No other variables showed a significant association.

Table 4.5

The association between the exposure of number of parks (continuous variable) and the objectively measured outcome of physical activity (CRP and IL-

6) were modeled. No significant associations ($p < 0.05$) were observed at any of the buffer regions analyzed. In addition, crude (univariable) and adjusted (multivariate) models did not show a linear relationship. Linearity assumptions for the modeled variables were not met.

Table 4.6

The association between the outcome of inflammation biomarkers (dichotomous variable) and the exposures of number of parks (continuous variable) was modeled. CRP was dichotomized into ‘High’ and ‘Low’ values with a cutoff of 3.0 mg/L. IL-6 was dichotomized into ‘High’ and ‘Low’ values with a cutoff of 2.0 pg/mL. Neither crude nor adjusted models yielded any significant associations (OR with 95% CI non-inclusive of 1.0).

Table 4.7

The association between the outcome of inflammation biomarkers (continuous) and the exposures of number of parks (categorical) was modeled. Categorized groups of ‘Low’, ‘Moderate’, and ‘High’ were determined for each specified buffer region (methodology described in the previous chapter, ‘III. Research Methods’). Buffer regions of 0.25mi and 0.50mi were excluded from analysis based on their values for derived quartiles having more than one zero value. No significant associations ($p < 0.05$) were observed for any of the buffer regions analyzed.

Table 4.8

The association between the outcome of inflammation biomarkers (dichotomized) and the exposure of number of parks (categorical) was modeled. The 'Low' values for both CRP and IL-6 were modeled and 'High' values were referent. For those with a moderate amount of parks in their surrounding 0.75mi radius buffer region the odds of having a 'Low' CRP value were 2.697 (95% CI: 1.261 – 5.767) and 2.863 (95% CI: 1.287 -6.370) times the odds of those with 'low' amount of parks in the crude and adjusted models respectively. For those with a moderate amount of parks in their surrounding 0.75mi radius buffer region the odds of having a 'Low' IL-6 value were 2.452 (95% CI: 1.134 – 5.308) and 2.542 (95% CI: 1.150 – 5.616) times the odds of those with 'low' amount of parks in the crude and adjusted models respectively. For those with a 'high' amount of parks in their surrounding 5.0mi radius buffer region the odds of having a 'Low' CRP value were 1.879 (95% CI: 1.109 – 3.184) and 1.819 (95% CI: 1.029 – 3.215) times the odds of those with 'low' amount of parks in the crude and adjusted models respectively. For those with a 'high' amount of parks in their surrounding 5.0mi radius buffer region the odds of having a 'Low' IL-6 value were 1.938 (95% CI: 1.144 – 3.298) and 1.907 (95% CI: 1.109 – 3.281) times the odds of those with 'low' amount of parks in the crude and adjusted models respectively. No other associations showed significant results.

Table 4.9

The association between the outcome of inflammation biomarkers (dichotomized) and the exposures of number of parks (categorical) was modeled. Covariates included in the final models for CRP and IL-6 were only those that were statistically significant ($p < 0.05$). CRP included covariates of gender and age, whereas IL-6 included gender only. Similar associations were seen in the adjusted models from Table 4.8. The 0.75mi and 5.0mi radius buffer regions showed increased odds of having ‘Low’ biomarker values for ‘Moderate’ and ‘High’ counts of parks, respectively. No other distance buffer radii showed significant associations.

Table 4.10

The crude association between the outcome of RAPA scores (self-reported) and the exposure of number of parks (continuous) was modeled. Separate comparisons were employed for those who met recommendations of physical activity and those that engaged in more than recommended physical activity against sedentary behavior. Because of separate comparisons those that did not meet the specific criteria were excluded. For the comparison of ‘meet recommendations’ to ‘sedentary’ the study population totaled 150. For the comparison of ‘over recommendation’ to ‘sedentary’ the study population totaled 101. No significant (p-value < 0.05) associations were observed.

Table 4.11

The adjusted association between RAPA scores (self-reported) and the number of parks (continuous) was modeled. Models were adjusted for education, employment status, gender and age. Separate comparisons were employed for those who met recommendations of physical activity and those that engaged in more than recommended physical activity against sedentary behavior. No significant (p-value < 0.05) associations were observed.

Table 4.12

The crude association between RAPA scores (self-reported) and the number of parks (categorical) was modeled. Separate comparisons were employed for those who met recommendations of physical activity and those that engaged in more than recommended physical activity against sedentary behavior. A significant association was observed at the 1.0mi radius buffer distance. For those with a 'moderate' amount of parks in their surrounding 1.0mi radius buffer region, the odds of meeting the recommended amount of physical activity were 0.358 (95% CI: 0.150 – 0.856) times the odds of being sedentary.

Table 4.13

The adjusted association between RAPA scores (self-reported) and the number of parks (categorical) was modeled. Models were adjusted for education, employment status, gender and age. Separate comparisons were employed for those who met recommendations of physical activity and those that engaged in more than recommended physical activity against sedentary behavior. No significant (p-value < 0.05) associations were observed.

Table 4.14

The adjusted association between RAPA scores (self-reported) and the number of parks (categorical) was modeled. Models were adjusted for gender only which were significant (p-value < 0.05). Separate comparisons were employed for those who met recommendations of physical activity and those that engaged in more than recommended physical activity against sedentary behavior. For those with a 'moderate' amount of parks in their surrounding 1.0mi radius buffer region the odds of meeting the recommended amount of physical activity were 0.353 (95% CI: 0.143 – 0.866) times the odds of being sedentary.

Table 4.15

The association between the outcome of armband PA data from HEALS participants (n=128; subset of only) and the exposures of number of recreational green spaces (parks) is modeled. Crude and adjusted associations are shown. Adjusted models are inclusive of education, employment status, gender and age. According to this analysis, a one unit increase in energy expenditure (kcal) directly decreases the number of parks in a 5.0mi buffer region by 1.2814 (p-value = 0.0061). In the adjusted model, a one unit increase in energy expenditure (kcal) decreases the number of parks in a 5.0mi buffer region by 0.8790 (p-value

= 0.0209). No other buffer regions reached statistical significance (p-value <0.05).

Table 4.16

The association between armband PA data from HEALS participants and the categorized number of recreational green spaces is modeled. The crude and adjusted associations are displayed. Adjusted models include covariates of education, employment status, gender and age. For the 5.0mile radius buffer, the amount of energy expended for those that have ‘high’ categorized park counts is 214.831kcals less than those with low park counts (p-value = (0.0107) after adjustment for education, employment status, gender and age. The amount of energy expended for those that have ‘moderate’ categorized park counts is 196.408 kcals less than those with low park counts (p-value = 0.0127) after adjustment for education, employment status, gender and age. Significant adjusted associations were also seen in the 1.50 mile buffer region comparing the ‘high’ amount of parks compared to ‘low’.

Table 4.17

The association between armband PA data from HEALS participants and the categorized number of recreational green spaces is modeled. The adjusted associations are displayed, accounting for gender and age covariates (statistically significant variables). Significant associations were seen at the 5.0

mile buffer for both ‘high’ to ‘low’ and ‘moderate’ to ‘low’ comparisons, 3.0 mile buffer comparing ‘moderate’ to ‘low’ and at 1.50 mile buffer comparing ‘high’ to ‘low’.

Table 4.1 Baseline Characteristics of Study Participants (before exclusion criteria applied)		
	Frequency	**Percentage / Mean (SD)**
Gender (n= 488)		
Female	440	90.16
Male	48	9.84
Education Level (n=484)		
8th grade or less	2	0.41
High school > x >8th grade	13	2.69
High school completed, no college	83	17.15
High school completed, some college	182	37.60
College completed	101	20.87
More than college completed	103	21.28
Employment Status(n=485)		
Yes, full time	244	50.31
Yes, part time	47	9.69
Retired	130	26.80
No	64	13.20
Age(years)	488	53.41 (11.4)
Weight (lbs)	484	213.76 (48.55)
Height (in)	485	64.32 (2.98)
BMI (kg/m^2)	484	36.33 (8.13)
Waist Circumference (in)	483	71.47 (35.03)
Hip (in)	484	81.98 (40.17)
Waist-to-Hip Ratio	483	0.87 (0.08)
Systolic Blood Pressure (mmHg)	484	133.38 (20.67)
Diastolic Blood Pressure (mmHg)	484	81.52 (11.75)
Fat Percent (%)	479	43.65 (8.19)
IL – 6 (pg/mL)	473	4.35 (20.05)
CRP (mg/L)	473	6.62 (14.81)
Parks in a Neighborhood (Additive buffer [1])		
0.00-0.25mi	507	0.51 (1.83)
0.00-0.50mi	507	1.67 (3.64)
0.00-0.75mi	507	3.63 (5.89)
0.00-1.00mi	507	6.41 (8.57)
0.00-1.50mi	507	15.03 (15.84)

0.00-3.00mi	507	60.12 (43.46)
0.00-5.00mi	507	140.36 (80.27)
Parks in a Neighborhood (Non-additive buffer [2])		
0.50mi	507	1.16 (2.75)
0.75mi	507	1.95 (4.13)
1.00mi	507	2.79 (5.55)
1.50mi	507	8.62 (11.17)
3.00mi	507	45.09 (34.27)
5.00mi	507	80.24 (50.81)

[1]Additive buffer is defined as the average amount of parks in that radius buffer region, inclusive of the previous buffers counts.
[2]Non-additive buffer is defined as the average amount of parks in that radius buffer region, exclusive of the previous buffers counts.

Table 4.2 Baseline Characteristics of Study Participants (after exclusion criteria applied)

N = 458		
	Frequency	**Percentage / Mean (SD)**
Gender		
Female	413	90.17
Male	45	9.83
Education Level		
8th grade or less	2	0.44
High school > x >8th grade	13	2.84
High school completed, no college	78	17.03
High school completed, some college	174	37.99
College completed	95	20.74
More than college completed	96	20.96
Employment Status		
Yes, full time	236	51.53
Yes, part time	45	9.83
Retired	118	25.76
No	59	12.88
Age(years)		53.36 (11.39)
Weight (lbs)		213.65 (48.70)
Height (in)		64.30 (3.01)
BMI (kg/m^2)		36.34 (8.17)

Waist Circumference (in)		71.09 (35.19)
Hip (in)		81.71 (40.36)
Waist-to-Hip Ratio		0.87 (0.08)
Systolic Blood Pressure (mmHg)		133.25 (20.82)
Diastolic Blood Pressure (mmHg)		81.47 (11.64)
Fat Percent (%)		43.63 (8.13)
IL – 6 (pg/mL)		4.38 (20.37)
CRP (mg/L)		6.63 (14.97)
Dichotomized Biomarkers		
CRP (mg/L)		
High (>3.0)	266	58.08
Low (≤3.0)	192	41.92
IL-6 (pg/mL)		
High (>2.0)	245	53.49
Low (≤2.0)	213	46.51
Parks in a Neighborhood (Additive buffer [1])		
0.00-0.25mi		0.53 (1.89)
0.00-0.50mi		1.73 (3.76)
0.00-0.75mi		3.62 (5.90)
0.00-1.00mi		6.47 (8.60)
0.00-1.50mi		14.91 (15.62)
0.00-3.00mi		59.75 (43.18)
0.00-5.00mi		139.98 (79.99)
Parks in a Neighborhood (Non-additive buffer [2])		
0.50mi		1.20 (2.83)
0.75mi		1.89 (4.08)
1.00mi		2.85 (5.69)
1.50mi		8.44 (10.82)
3.00mi		44.84 (33.87)
5.00mi		80.23 (50.89)
[1]Additive buffer is defined as the average amount of parks in that radius buffer region, inclusive of the previous buffers counts. [2]Non-additive buffer is defined as the average amount of parks in that radius buffer region, exclusive of the previous buffers counts.		

Table 4.3 – Association of Descriptive Statistics Before and After Exclusion Criteria			
	Before (n = various)	**After (n = 458)**	
Characteristic	**Frequency /Mean[1] (SD)**	**Frequency/ Mean[1] (SD)**	**P-value[2]**
Gender			> 0.9999
Female	440	413	
Male	48	45	
Education Level			0.8816
8th grade or less	2	2	
High school > x >8th grade	13	13	
High school completed, no college	83	78	
High school completed, some college	182	174	
College completed	101	95	
More than college completed	103	96	
Employment Status			0.0758
Yes, full time	244	236	
Yes, part time	47	45	
Retired	130	118	
No	64	59	
Age(years)	53.41 (11.4)	53.36 (11.39)	0.7203
Weight (lbs)	213.76 (48.55)	213.65 (48.70)	0.8301
Height (in)	64.32 (2.98)	64.30 (3.01)	0.3953
BMI (kg/m^2)	36.33 (8.13)	36.34 (8.17)	0.9194
Waist Circumference (in)	71.47 (35.03)	71.09 (35.19)	0.3094
Hip (in)	81.98 (40.17)	81.71 (40.36)	0.5488
Waist-to-Hip	0.87 (0.08)	0.87 (0.08)	0.5494

Ratio			
Systolic Blood Pressure (mmHg)	133.38 (20.67)	133.25 (20.82)	0.5714
Diastolic Blood Pressure (mmHg)	81.52 (11.75)	81.47 (11.64)	0.7113
Fat Percent (%)	43.65 (8.19)	43.63 (8.13)	0.7446
IL – 6 (pg/mL)	4.35 (20.05)	4.38 (20.37)	0.4291
CRP (mg/L)	6.62 (14.81)	6.63 (14.97)	0.9283

[1] Frequencies were displayed for categorical variables and means (Standard deviations) for continuous variables.
[2] P-values were determined from paired t-tests for continuous variable and chi-squared analysis for categorical. For continuous variables that had unequal variances the Satterthwaite value was reported. For categorical if the any expected cell counts were < 5 the Fischer's Exact p-value was reported.

Table 4.4 Univariable Analyses of Potential Confounders/Effect Modifiers

	C-Reactive Protein	**Interleukin- 6**
	Beta coefficient (p-value)	
Education[1]		
8th grade or less	-0.2138 (0.9840)	-4.6111 (0.7503)
More than 8th grade and less than high school	-1.6668 (0.7048)	-2.4328 (0.6848)
High school completed no college	3.7932 (0.0946)	0.1298 (0.9665)
High school completed some college	1.2982 (0.4928)	-3.5977 (0.1628)
College completed	0.1129 (0.9582)	-3.1189 (0.2878)
Employment[2]		
Retired	-2.6682 (0.2612)	2.3359 (0.4710)
Yes, part time	-1.9872 (0.5003)	-0.1377 (0.9727)
Yes, full time	0.2377 (0.9127)	2.1163 (0.4744)
Gender		
Female	4.7821 (0.0407)*	2.7144 (0.3951)

Age	-0.1019 (0.0957)	0.1000 (0.2306)
*Significant association ($p < 0.05$) [1]Reference Level = 'More than college completed' [2]Reference Level = 'No'		

Table 4.5 Association between inflammation biomarkers (continuous) and recreational green space (park) counts							
	Buffer Distances[1] (miles)						
	0.25	**0.50**	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Biomarkers	**Beta coefficient (p-value)**						
CRP							
Crude[2]	-0.239 (0.518)	-0.053 (0.777)	-0.027 (0.823)	0.004 (0.963)	1.162 (0.943)	-0.007 (0.676)	-0.005 (0.567)
Adjusted[3]	-0.295 (0.428)	-0.126 (0.499)	-0.043 (0.716)	0.006 (0.941)	0.011 (0.803)	-0.006 (0.737)	-0.003 (0.754)
IL-6							
Crude[2]	-0.185 (0.713)	0.006 (0.980)	-0.039 (0.808)	-0.037 (0.739)	-0.042 (0.491)	-0.003 (0.901)	-0.002 (0.857)
Adjusted[3]	-0.418 (0.412)	-0.061 (0.810)	-0.035 (0.831)	-0.023 (0.839)	-0.032 (0.603)	-0.002 (0.933)	-0.004 (0.755)
[1] Distance in miles is indicative of radius length of buffer region. [2]Crude model: biomarker = buffer distance [3]Adjusted model: biomarker = buffer distance + education + employment status + gender + age							

Table 4.6 – Association[1] between inflammation biomarkers (dichotomized) and recreational green space (park) counts							
	Buffer Distances[2] (miles)						
	0.25	**0.50**	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Biomarkers	**Odds ratio (95% CI)**						
CRP							
Crude[3]	0.993 (0.901, 1.095)	1.014 (0.964, 1.066)	1.016 (0.983, 1.049)	1.005 (0.983, 1.027)	1.002 (0.990, 1.014)	0.999 (0.995, 1.003)	0.998 (0.996, 1.000)
Adjusted[4]	1.002 (0.904, 1.110)	1.000 (0.948, 1.054)	1.009 (0.975, 1.044)	1.005 (0.982, 1.029)	1.004 (0.991, 1.017)	0.999 (0.994, 1.003)	0.998 (0.995, 1.001)

IL-6							
Crude[3]	1.040 (0.939, 1.153)	1.019 (0.970, 1.072)	1.004 (0.973, 1.036)	1.002 (0.980, 1.023)	1.003 (0.991, 1.015)	1.000 (0.995, 1.004)	0.998 (0.996, 1.00)
Adjusted[4]	1.030 (0.928, 1.143)	1.010 (0.960, 1.063)	1.000 (0.969, 1.032)	1.000 (0.978, 1.023)	1.003 (0.991, 1.015)	1.000 (0.995, 1.004)	0.998 (0.995, 1.000)

[1]The modeled association is ‘High’ CRP/IL-6 values vs. ‘Low’. Low’ values are defined as < 3.0 mg/L and < 2.0 pg/mL for CRP and IL-6 respectively.
[2] Distance in miles is indicative of radius length of buffer region.
[3] Crude model: biomarker = buffer distance counts
[4]Adjusted model: biomarker = buffer distance counts + education + employment status + gender +age

Table 4.7 – Association between inflammation biomarkers (continuous) and recreational green space (park) counts[1] (categorical)

	Buffer Distances[2] (miles)				
	0.75	**1.0**	**1.50**	**3.0**	**5.0**
Biomarkers	**Beta coefficient (p-value)**				
CRP					
Crude[3]					
High	-0.883 (0.543)	-0.538 (0.746)	-1.383 (0.471)	-2.036 (0.306)	-0.538 (0.785)
Moderate	-2.380 (0.394)	-1.930 (0.268)	-1.825 (0.278)	-3.175 (0.070)	2.343 (0.175)
Adjusted[4]					
High	-0.799 (0.583)	-0.620 (0.710)	-1.130 (0.561)	-1.964 (0.328)	0.020 (0.992)
Moderate	-1.793 (0.523)	-2.179 (0.2140)	-1.627 (0.3420)	-3.081 (0.089)	2.628 (0.1290)
IL-6					
Crude[3]					
High	-1.586 (0.421)	-1.375 (0.542)	-0.178 (0.946)	-1.114 (0.681)	-0.853 (0.750)
Moderate	-2.171 (0.568)	-2.854 (0.228)	-0.048 (0.983)	-0.435 (0.856)	2.814 (0.229)

	0.75	1.0	1.50	3.0	5.0
Adjusted[4]					
High	-1.764 (0.376)	-1.114 (0.625)	0.049 (0.985)	-1.139 (0.680)	-1.187 (0.661)
Moderate	-2.183 (0.570)	-3.241 (0.177)	0.081 (0.972)	-0.798 (0.748)	2.242 (0.345)

[1]'Low' counts of parks are the referent level.
[2]Distance in miles is indicative of radius length of buffer region.
[3] Crude model: biomarker = buffer distance counts
[4] Adjusted model: biomarker = buffer distance counts + education + employment status + gender +age

Table 4.8 – Association between inflammation biomarkers (dichotomous) and recreational green space (park) counts[1] (categorical)

	Buffer Distances[2] (miles)				
	0.75	**1.0**	**1.50**	**3.0**	**5.0**
Biomarkers	**Odds ratio (95% CI)**				
CRP					
Crude[3]					
High	1.078 (0.731, 1.588)	0.839 (0.537, 1.310)	0.978 (0.584, 1.639)	1.285 (0.751, 2.198)	1.879* (1.109, 3.184)
Moderate	2.697* (1.261, 5.767)	1.164 (0.735, 1.844)	1.248 (0.796, 1.955)	1.408 (0.876, 2.263)	1.040 (0.653, 1.658)
Adjusted[4]					
High	1.136 (0.746, 1.729)	0.860 (0.531, 1.393)	0.892 (0.506, 1.572)	1.390 (0.777, 2.487)	1.819* (1.029, 3.215)
Moderate	2.863* (1.287, 6.370)	1.314 (0.800, 2.157)	1.366 (0.837, 2.231)	1.460 (0.860, 2.478)	1.052 (0.636, 1.743)
IL-6					
Crude[3]					
High	1.003 (0.684, 1.470)	1.148 (0.742, 1.775)	1.130 (0.680, 1.878)	1.250 (0.736, 2.123)	1.938* (1.144, 3.298)
Moderate	2.453* (1.134,	1.022 (0.646,	1.291 (0.828,	1.500 (0.940,	1.383 (0.872,

	5.308)	1.616)	2.014)	2.394)	2.193)
Adjusted[4]					
High	1.039 (0.701, 1.540)	1.180 (0.753, 1.850)	1.119 (0.660, 1.897)	1.310 (0.757, 2.267)	1.907* (1.109, 3.281)
Moderate	2.542* (1.150, 5.616)	1.066 (0.664, 1.711)	1.315 (0.827, 2.092)	1.518 (0.925, 2.494)	1.455 (0.903, 2.345)

*p <0.05 considered a statistically significant odds ratio
[1]'Low' counts of parks are the referent level.
[2] Distance in miles is indicative of radius length of buffer region
[3]Crude model: biomarker = buffer distance counts
[4]Adjusted model: biomarker = buffer distance counts + education + employment status + gender +age

Table 4.9 - Association between inflammation biomarkers (dichotomous) and recreational green space (park) counts (categorical)- Final Models

	Buffer Distances[1] (miles)				
	0.75	**1.0**	**1.50**	**3.0**	**5.0**
Biomarkers	**Odds ratio (95% CI)**				
CRP[2]					
Adjusted					
High	1.134 (0.754, 1.706)	0.902 (0.564, 1.443)	0.938 (0.543, 1.622)	1.377 (0.785, 2.414)	1.811* (1.038, 3.159)
Moderate	2.723* (1.242, 5.970)	1.299 (0.803, 2.101)	1.325 (0.828, 2.122)	1.370 (0.831, 2.257)	1.031 (0.630, 1.690)
IL-6[3]					
Adjusted					
High	1.032 (0.702, 1.518)	1.170 (0.754, 1.817)	1.112 (0.666, 1.855)	1.292 (0.758, 2.202)	1.913* (1.125, 3.254)
Moderate	2.532* (1.165, 5.503)	1.058 (0.667, 1.681)	1.324 (0.846, 2.074)	1.479 (0.923, 2.368)	1.427 (0.896, 2.272)

*p <0.05 considered a statistically significant odds ratio
[1]Distance in miles is indicative of radius length of buffer region
[2]Adjusted model is defined as: CRP = count + gender + age
[3]Adjusted model is defined as: IL-6 = count +gender

Table 4.10 Crude Associations between RAPA scores and Recreational Green Space (park) Counts (continuous)

	Buffer Distances[1] (miles)						
	0.25	**0.50**	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Physical Activity Comparison	**Odds ratio (95% CI)**						
Sedentary vs. Meet Recommendation[2]	0.950 (0.798, 1.131)	0.919 (0.833, 1.013)	0.961 (0.903, 1.023)	0.979 (0.938, 1.022)	1.003 (0.980, 1.027)	0.997 (0.988,1.005)	0.999 (0.995, 1.003)
Sedentary vs. Over Recommendation[3]	0.779 (0.531, 1.144)	0.941 (0.839, 1.056)	0.967 (0.895, 1.045)	0.988 (0.933, 1.046)	1.002 (0.971, 1.034)	1.000 (0.989, 1.011)	1.000 (0.996, 1.005)

[1]Distance in miles is indicative of radius length of buffer region.
[2]Modeling odds ratios for Meet Recommendation vs. Sedentary (N = 150)
[3]Modeling odds ratios for Over Recommendation vs. Sedentary (N = 101)

Table 4.11 Adjusted[1] Associations between RAPA scores and Recreational Green Space (park) Counts

	Buffer Distances[2] (miles)						
	0.25	**0.50**	**0.75**	**1.0**	**1.50**	**3.0**	**5.0**
Physical Activity Comparison	**Odds ratio (95% CI)**						
Sedentary vs. Meet Recommendation[3]	1.001 (0.834,1.202)	0.946 (0.855, 1.047)	0.972 (0.909, 1.039)	0.979 (0.934, 1.025)	1.007 (0.981, 1.034)	0.998 (0.988, 1.008)	1.000 (0.996, 1.005)
Sedentary vs. Over Recommendation[4]	0.779 (0.524,1.159)	0.954 (0.841, 1.082)	0.972 (0.893, 1.059)	0.988 (0.926, 1.054)	1.000 (0.964, 1.037)	1.001 (0.988, 1.013)	1.002 (0.996, 1.007)

[1]Adjustment for education, employment, gender and age.
[2]Distance in miles is indicative of radius length of buffer region.
[3]Modeling odds ratios for Meet Recommendation vs. Sedentary (N = 150)
[4]Modeling odds ratios for Over Recommendation vs. Sedentary (N = 101)

Table 4.12 Crude Associations Between RAPA scores and Recreational Green Space (park) Counts (categorical)					
	Buffer Distances[1]** (miles)				
	0.75	1.0	1.50	3.0	5.0
Physical Activity Comparison	**Odds ratio (95% CI)**				
Sedentary vs. Meet Recommendation[2]					
High	0.804 (0.401, 1.613)	0.527 (0.236, 1.177)	0.862 (0.343, 2.162)	0.990 (0.327, 2.995)	0.737 (0.298, 1.822)
Moderate	0.625 (0.155, 2.518)	0.358* (0.150, 0.856)	0.960 (0.440, 2.093)	0.613 (0.262, 1.436)	0.957 (0.406, 2.254)
Sedentary vs. Over Recommendation[3]					
High	1.233 (0.539, 2.819)	0.821 (0.316, 2.133)	1.354 (0.439, 4.176)	1.093 (0.276, 4.329)	1.000 (0.360, 2.779)
Moderate	2.025 (0.504, 8.138)	1.022 (0.400, 2.612)	1.664 (0.636, 4.355)	1.111 (0.391, 3.157)	0.696 (0.250, 1.936)

* p <0.05 considered a statistically significant odds ratio
[1]Distance in miles is indicative of radius length of buffer region. Buffer distances had a reference level of 'Low'.
[2]Modeling odds ratios for Meet Recommendation vs. Sedentary (N = 150)
[3]Modeling odds ratios for Over Recommendation vs. Sedentary (N = 101)

Table 4.13 Adjusted[1] Associations Between RAPA scores and Recreational Green Space (park) Counts (categorical)					
	Buffer Distances[2] (miles)				
	0.75	1.0	1.50	3.0	5.0
Physical Activity Comparison	**Odds ratio (95% CI)**				
Sedentary vs. Meet Recommendation[3]					
High	0.920 (0.419, 2.018)	0.570 (0.238, 1.366)	1.049 (0.388, 2.837)	1.094 (0.333, 3.600)	1.056 (0.385, 2.898)

Moderate	0.547 (0.118, 2.541)	0.409 (0.153, 1.097)	1.319 (0.549, 3.171)	0.904 (0.345, 2.373)	1.319 (0.507, 3.428)
Sedentary vs. Over Recommendation[4]					
High	1.649 (0.629, 4.322)	0.832 (0.275, 2.518)	1.258 (0.339, 4.663)	1.404 (0.291, 6.784)	1.271 (0.379, 4.259)
Moderate	3.067 (0.528, 17.825)	1.366 (0.450, 4.144)	2.358 (0.748, 7.428)	1.355 (0.403, 4.560)	0.840 (0.256, 2.751)

[1] Adjustment for education, employment, gender and age.
[2]Distance in miles is indicative of radius length of buffer region. Buffer distances had a reference level of ‘Low’.
[3]Modeling odds ratios for Meet Recommendation vs. Sedentary (N = 150)
[4]Modeling odds ratios for Over Recommendation vs. Sedentary (N = 101)

Table 4.14 – Significant Covariate Adjusted[1] Associations Between RAPA scores and Recreational Green Space (park) Counts (categorical)

	Buffer Distances[2] (miles)				
	0.75	**1.0**	**1.50**	**3.0**	**5.0**
Physical Activity Comparison	**Odds ratio (95% CI)**				
Sedentary vs. Meet Recommendation[3]					
High	0.838 (0.411, 1.710)	0.542 (0.238, 1.232)	0.867 (0.336, 2.232)	1.039 (0.334, 3.233)	0.800 (0.315, 2.031)
Moderate	0.690 (0.167, 2.856)	0.353* (0.143, 0.866)	1.031 (0.463, 2.293)	0.689 (0.288, 1.653)	1.059 (0.438, 2.558)

Sedentary vs. Over Recommendation[4]					
High	1.371 (0.577, 3.254)	0.860 (0.320, 2.314)	1.111 (0.340, 3.631)	1.063 (0.258, 4.380)	0.974 (0.337, 2.811)
Moderate	2.123 (0.501, 8.998)	1.039 (0.392, 2.754)	1.613 (0.597, 4.355)	0.988 (0.336, 2.908)	0.690 (0.239, 1.996)

[1]Adjustment for gender.
*Significant odds ratio (p-value < 0.05).
[2] Distance in miles is indicative of radius length of buffer region. Buffer distances had a reference level of 'Low'.
[3]Modeling odds ratios for Meet Recommendation vs. Sedentary (N = 150)
[4]Modeling odds ratios for Over Recommendation vs. Sedentary (N = 101)

Table 4.15 Association between energy expenditure (kcals) and recreational green space (park) counts

n=128	Buffer Distances[1] (miles)						
	0.25	0.50	0.75	1.0	1.50	3.0	5.0
Models	Beta coefficient (p-value)						
Crude[2]	10.041 (0.646)	5.989 (0.589)	0.654 (0.928)	-0.765 (0.874)	-1.736 (0.522)	-1.041 (0.306)	-1.281* (0.006)
Adjusted[3]	28.766 (0.081)	12.233 (0.149)	-1.866 (0.741)	-3.715 (0.328)	-3.848 (0.068)	-1.032 (0.203)	-0.879* (0.021)

*Significant value
[1] Distance in miles is indicative of radius length of buffer region.
[2]Crude model: energy expenditure = buffer distance
[3]Adjusted model: energy expenditure = buffer distance + education + employment status + gender + age

Table 4.16 – Association between energy expenditure (kcals) and recreational green space (park) counts[1] (categorical)

n=128	Buffer Distances[2] (miles)				
	0.75	1.0	1.50	3.0	5.0
Models	Beta coefficient (p-value)				

Crude[3]					
High	-25.1892 (0.7587)	-38.1347 (0.6705)	-108.909 (0.3029)	-186.193 (0.1314)	-294.574* (0.0051)
Moderate	-18.1248 (0.9144)	-206.955 (0.0502)	-189.977* (0.0428)	-191.139* (0.0476)	-267.174* (0.0067)
Adjusted[4]					
High	-10.3291 (0.8737)	-79.7034 (0.2709)	-216.043* (0.0097)	-106.256 (0.2785)	-214.831* (0.0107)
Moderate	70.5564 (0.5855)	-109.169 (0.1944)	-94.5733 (0.2022)	-122.759 (0.1151)	-196.408* (0.0127)

*Significant association
[1]'Low' counts of parks are the referent level.
[2]Distance in miles is indicative of radius length of buffer region.
[3] Crude model: energy expenditure = buffer distance counts
[4] Adjusted model: energy expenditure = buffer distance counts + education + employment status + gender +age

Table 4.17 – Association between energy expenditure (kcals) and recreational green space (park) counts[1] (categorical) – Final Model

n=128	Buffer Distances[2] (miles)				
	0.75	**1.0**	**1.50**	**3.0**	**5.0**
Models	**Beta coefficient (p-value)**				
Adjusted[3]					
High	-44.379 (0.4784)	-90.611 (0.1981)	-227.895* (0.0047)	-145.825 (0.1222)	-236.831* (0.0032)
Moderate	6.172 (0.9618)	-144.166 (0.0736)	-131.415 (0.0636)	-166.171* (0.0237)	-222.478* (0.0031)

*Significant association
[1]'Low' counts of parks are the referent level.
[2] Distance in miles is indicative of radius length of buffer region.
[3] Adjusted model: energy expenditure = buffer distance counts + gender + age

CHAPTER 5

CONCLUSION/ DISCUSSION

5.1 Summary of Results

Significant associations of physical activity outcomes (objective and subjective) with the density of recreational green spaces that surround a participant's residence (at various buffer sizes) were inconsistent. No visible linear trend was observed among all the distance radii tested and selected measures of physical activity.

Objective measures of PA, specifically inflammation biomarkers (CRP and IL-6) showed a statistically significant reduction in the odds of higher inflammation values when counts of parks were categorically higher. We saw this for the buffer regions of 0.75 and 5.0 miles for both biomarkers. The associations were modified by the addition of covariates gender and age but still remained significant. Though there was not statistically significant evidence, a larger magnitude of odds was observed for the smaller buffer region (0.75 miles) than the larger (5.0 miles). Adjustment for gender and age was necessary (significant p-values) in the final models of CRP. Only gender for the final IL-6 model was included as it was significant and necessary to be adjusted.

The subjective measure of physical activity via self-reported RAPA questionnaire showed largely non-significant results across all analyzed buffer regions. One association (1.0mi radii buffer) showed an inverse relationship of meeting the recommended amount of physical activity and having a 'moderate' amount of parks in that buffer region compared to being sedentary.

Additionally, measurements of energy expenditure for HEALS participants were analyzed. An unintuitive, negative association was seen between the kilocalories that were expended (data via Armband) and the number of recreational green spaces (both continuous and categorized predictor variables) at the highest buffer radii area, 5.0 miles. For all statistically significant buffer region results it was seen that higher categorized number of parks was associated with decreased energy expenditure.

5.2 Significance of findings

Previous research has had inconclusive results in relation to the built environment and physical activity in the inhabitants of that area (See Table 1.1). The results of my research add to this literature that recreational green space proximity to residence has an inconsistent relationship on influence of physical activity at varying buffer distances.

Contrary to what was expected, an inverse relationship was observed in the self-report measure of RAPA for HEALS participants. Categorized 'moderate' counts of parks in a 1.0mi buffer region decreased the odds of meeting physical activity recommendations in contrast to a sedentary lifestyle after adjustment for gender. To our knowledge no other study has seen this particular relationship at statistical significance. However, it is plausible that low number of participants (n=150) in this specific analysis could have invalidated this result, especially with reproducibility.

An inverse relationship was also found in the results of energy expenditure (measured via Sensewear® armbands) and park counts. At the 5.0 mile radii buffer distance, as the amount of parks increased, the energy expenditure decreased. Categorization of the number of parks into 'low', 'moderate', and 'high' yielded the same association at this distance even after adjustment for significant covariates of age and gender. Similar negative relationships were seen at 3.0 and 1.5 mile radii comparing a higher count group to the lowest. Meaning for this association is undetermined, although it is possible that in neighborhoods that have higher number of parks there are other influences that explain lack of energy expenditure. Potentially parks may also be difficult to get to if there is no easy route, whether that be sidewalks or street connectivity. It has been observed in two studies that more parks were being used for sedentary activity such as sitting on park benches rather than for physical exertion (D. A. Cohen et al., 2007; Floyd, Spengler, Maddock, Gobster, & Suau, 2008). In this way it might be the kind of park activities and design that a park promotes that is of importance.

Unique to this analysis is the finding of an association of higher park counts with lower inflammation biomarkers at 0.75 mile and 5.0 mile radii buffer distances around residences, after adjustment for significant covariates. Although 0.75 miles has been utilized as a marker of 15-minute neighborhood walkability (Colabianchi et al., 2014; Colabianchi et al., 2007) , 5.0 miles has not seen an association with physical activity outcomes. This buffer region, much more than walking distance for an obese/overweight individual may shed light on the distance one is willing to travel by other means for physical activity. This outstretched "neighborhood" from a residence may be inclusive of locations that obese/overweight individuals may drive to in order to participate in physical activity. This information could be especially informative for exercise regiments and interventions that employ a study location for completing physical activity.

Additionally, inflammation biomarkers have been used infrequently as indicators for physical activity in relation to amount of recreational opportunity available to persons (park counts). These measures of physical activity are in opposition to most studies that employ moderate to vigorous physical activity values obtained from accelerometer recordings (Carlson et al., 2012; Hall & McAuley, 2010; Jilcott et al., 2007; Saelens et al., 2012; Salvo et al., 2014; Strath et al., 2012). Inflammation biomarkers are affected by not only physical activity but diet. Because of this, objective analysis of the combined effect of physical activity and diet on health can be observed for the future. While this particular study did not employ adjustment for diet, both studies (HEALS and SISTAS) are inclusive of dietary intervention protocol and assessments of such throughout.

The results of this study suggest that there may be a relationship with number of parks around a person's residence and their physical activity engagement for adult, overweight/obese African-Americans. Gender and age may alter this association. Proximity to parks that are within walking distance

(0.75 miles) or driving distance (5.0 miles) may provide added support for reducing high inflammation which can be influential of poorer health outcomes.

5.3 Strengths and weaknesses

There were several strengths and limitations of this study. One of the main limitations of this work was the complexity and completeness of designated parks obtained for South Carolina. No single entity (government or otherwise) was able to provide a comprehensive directory of recreational parks in SC and often polygons of park boundaries were estimated and/or derived from given acreage values. Despite this, listings of parks/recreational green spaces were identified within the state of South Carolina for this analysis to the best of our knowledge. In addition, use and safety of parks/recreational green spaces was unknown and could not be determined for from this dataset.

Another potential limitation of this study was the accuracy of socioeconomic status and education utilized. Self-report measures are potentially inclusive of bias. It is also possible that certain measures reported, such as employment status, might not depict the intended measure of SES accurately. Regardless of this possibility, the self-reported measures of gender and age showed a significant relationship with physical activity outcomes respectively.

Due to missing outcome, covariate or clinic data, 49 people were excluded. However, the demographics of these people did not differ significantly from those who were included in the final study analysis (Table 4.3). It is unlikely that these individuals would have altered the associations and that selection bias was in effect.

Although this study had limitations in its structure, it also had a large number of strengths. Since the data was only being analyzed at baseline for all of these participants the effect of intervention was not a factor and a cross-sectional analysis could be completed. Also, the inclusion criteria of participants in both the SISTAS and HEALS studies employed an overweight or obese criteria of standards for BMI. In this way the strong correlation that BMI has with physical activity could be excluded for analysis purposes. Another strength of this study was the employment of both objective and subjective measures of physical activity. In this way the assessment of physical activity in participants was not based solely on self-reported measures as has been done previously and can be inclusive of social desirability bias.

Lastly, this study was conducted on a specific population (African Americans) in South Carolina that warrants additional research. As has been previously stated, South Carolina has the 10th highest adult obesity rate in the United States (Foundation, 2015a). Because of this, insight into minority populations and those factors that might contribute to alteration of unhealthy lifestyles are crucial to modification of this statistic.

5.4 Future research

Although inconsistent, higher amounts of parks in a defined residential surrounding showed a reduction in odds of higher inflammation biomarkers.

Further analyses of this dataset should examine the effect closer, inclusive of dietary intake which has been seen to reduce inflammation as well(Ridker, 2005). Utilizing inflammation biomarkers as a component to objectively asses physical activity modification by recreational green space may shed more light on the association than other measures.

In addition, a more comprehensive mapping of the parks and other recreational opportunities (gyms, local high schools, and walking accessible neighborhoods) should be explored for all states to enhance studies looking at physical activity opportunities. Widening the breadth of knowledge on these entities can advance future epidemiologic studies aimed to assess physical activity. It is also possible that this information could inform neighborhood planning, inclusive of county and city entities, as to the optimal environment for adults to promote physical activity.

To extract even more information from these participants future research might employ a longitudinal analysis of the intervention method utilized. In this way the encouragement of increasing physical fitness and troubleshooting barriers to physical activity in adult, overweight/obese, African-American populations can be analyzed for effectiveness of treatment.

Additionally, the influence of stress and safety of environment to exercise can be investigated to possibly modify this association. Park accessibility and willingness to exercise in older adults may provide information on the types of environments that promote physical activity in older adults.

In conclusion, more studies are necessary to illuminate the relationship that physically active built environments have on adult African-American populations that are overweight/obese. While significant results were observed for select measures of recreational green space (parks), no linear trend was observed and warrants further investigation. These results add to the body of literature that have found inconsistent results between built environments and physical activity measures at varying distances around residence.

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