CORRESPONDENCE OF DIRECTLY AND INDIRECTLY MEASURED BUILT ENVIRONMENT ATTRIBUTES AND PHYSICAL ACTIVITY ADOPTION AMONG AFRICAN AMERICAN AND HISPANIC OR LATINA WOMEN.

A Dissertation for the Degree
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Abstract

Ethnic minority women report poorer health outcomes and attitudes and are more vulnerable to overweight and/or obesity compared to Caucasian women. Epidemiological studies and ecologic models of health behavior suggest that built environmental factors are associated with health behaviors, like physical activity (PA), that can help to prevent obesity and its many comorbidities. Despite growth and development in this field of research, many questions remain about the relationship between the built environment and perceptions about the built environment, and whether accurate perceptions are important for PA adoption. The objectives of the study were (1) to measure the concordance of directly measured and indirectly measured neighborhood attributes and (2) to determine the correlates of the concordance between directly and indirectly measured built environment attributes among separate samples of African American and Hispanic or Latina women (3) to determine whether there is an association between concordance and PA adoption among African American and Hispanic or Latina women. Community dwelling African American and Hispanic or Latina women participating in an ongoing HIP study self-reported their environmental perceptions at baseline (T1). In order to assess longitudinal PA levels and explore ethnic differences of neighborhood perceptions, we compared objectively measured neighborhood attributes with self-reported neighborhood attributes for African American and Hispanic or Latina women. Participants' (*N*=409) average BMI was classified as obese (*M* BMI=34.5

kg/m^2, *SD*=7.9) and the mean body fat percentage was 42.8% (*SD*=7.1). BMI, body fat percentage, PA and ethnicity were not significantly associated with any built environment attribute, and no multinomial regression model significantly predicted indirectly measured built environment attributes. Repeated measures analyses suggested no significant relationships between any built environment attribute concordance value and PA adoption for total self-reported or objectively measured PA. Self-reported PA significantly increased over time ($F(1,184)=7.82$, $p=.006$), and this increase did not vary by ethnicity or any built environment attribute concordance value. Being less familiar with certain built environment attributes may *not* be associated with PA adoption. In an effort to promote PA, community leaders and investigators must consider the complex associations between built environment attribute concordance and PA adoption, particularly among the vulnerable population of minority women.

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CHAPTER 1

Introduction

Rationale for Study

Despite growth and development in this field of research, many questions remain about the relationship between the built environment and perceptions about the built environment, and whether accurate perceptions are important for physical activity (PA) adoption. Many studies have associated built environment attributes or perceptions of built environment attributes to various types of PA (See Figure 1 below), but few studies have investigated the relationship between built environment attributes and perceptions of built environment attributes.

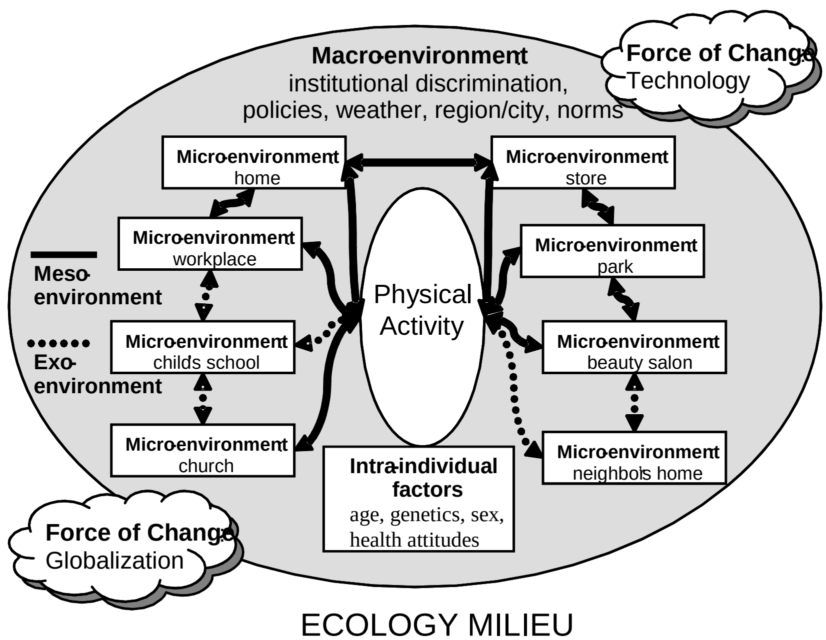

Figure 1: Ecological Model of Physical Activity

(Lee and Cubbin, 2009)

No studies have associated the relationship between the directly measured built environment and the indirectly measured built environment (i.e. perceptions about the built environment) to PA adoption, an important health behavior (See Figure 2 below).

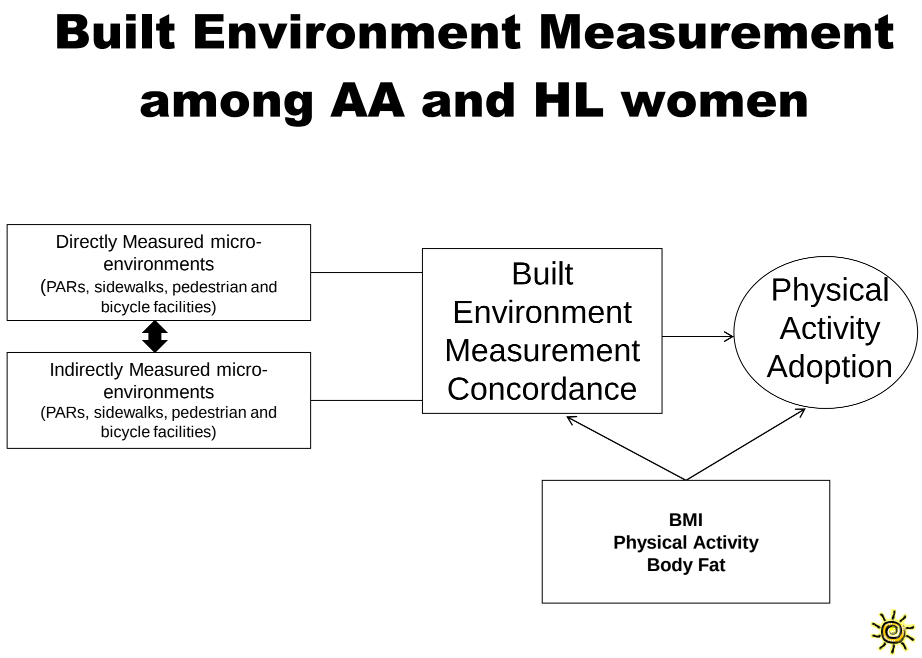

Figure 2: Built Environment Measurement among AA and HL women

Built environments that do not support healthful behaviors make it difficult for residents to adopt and maintain PA, regardless of individual or cultural attributes (Sallis et al., 1998; Sallis and Owen, N., 1997; Spence, 2003). Built environments can be measured directly (using objective field assessments) or indirectly (using self-report questionnaires). Direct built environment measures may provide objective data, unbiased by resident perceptions, as well as specific evidence for policy change impacting urban planning and transportation (significant correlates of adopting and maintaining PA). Indirect, self-reported measures of the built environment have been associated with PA

(Bengoechea, 2005; Foster & Giles-Corti, 2008; Velasquez, Holahan, & You, 2009). However, concordance of direct and indirect measures is inconsistent (Foster & Giles-Corti, 2008; Gebel, Bauman, & Owen, 2009; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007). Individuals who are less physically active may be more likely to misperceive their built environment as compared to those who more physically active (Gebel, Bauman, & Owen, 2009), suggesting that the concordance or non-concordance of direct and indirect built environmental measurement may be dynamic and related to PA. Greater familiarity with one's environment may provide greater incentive to be physically active in it, but few studies have systematically investigated this relationship.

Further, ethnic minority women report lower levels of PA (Kruger, Yore, & Kohl, 2008) and are at higher risk for obesity and its comorbidities as compared to Caucasians (Ogden et al., 2006; USDHHS, 1996) and health attitudes and behaviors can differ by ethnicity (Gordon-Larsen, McMurray and Popkin,1999; Harris, Walters and Waschull, 1991; Stern et al.,1982). PA adoption is an essential component for obesity prevention and treatment. Studies that investigate built environment measurement factors related to the adoption of PA are extremely important as consistent evidence suggests that neighborhood characteristics and health behaviors are significantly related (Sallis, Bauman, & Pratt, 1998; Sallis and Owen, N., 1997; Spence, 2003). This dissertation intends to investigate these relationships among a highly vulnerable population in which no studies exist.

Problem Statement, Principal Research Questions, Hypothesis

Little is known about how directly measured built environment attributes relates to indirectly measured environmental perceptions for female minority populations. I will address two principal research questions and one general hypothesis in this dissertation.

The principal questions I will address are: 1) What is the strength and direction of the concordance between directly and indirectly measured built environment attributes and does this relationship differ among separate samples of African American (AA) and Hispanic or Latina (HL) women? and 2) What are the correlates of the concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women?

The general hypothesis I will address is: 1) A higher concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women will be associated with greater PA adoption from time 1 (baseline) to time 2 (post intervention). PA will be measured objectively using accelerometry and using self-reported interview-administered questionnaires.

Specific Research Questions and Hypotheses

This study involves secondary analyses based on data from the ongoing *Health is Power* (HIP) project. The goals of HIP were (1) to determine whether a 24 week, social cohesion intervention (SOCO) was more effective for increasing PA in comparison to a fruit and vegetable comparison condition in AA and HL women, (2) to determine whether PA is more effectively maintained by SOCO participants who reside in high supportive PA environments in comparison to SOCO participants who reside in low supportive PA environments. The project is now in its final year of funding and in the process of data analyses and dissemination.

AA and HL participants were randomized into two different treatment groups (Vegetable and Fruit or PA). See Figure 3 below. The effect of group membership (if any) on concordance values will be tested in Research Question 1. Because PA levels differences (calculated from T1 to T2) did not significantly differ by treatment group (Lee et al, in press) (i.e. treatment group did not significantly affect PA adoption), both treatment groups (Vegetable and Fruit and PA) will be collapsed into two separate samples based only on ethnicity (i.e. AA and HL) to test Hypothesis 1.

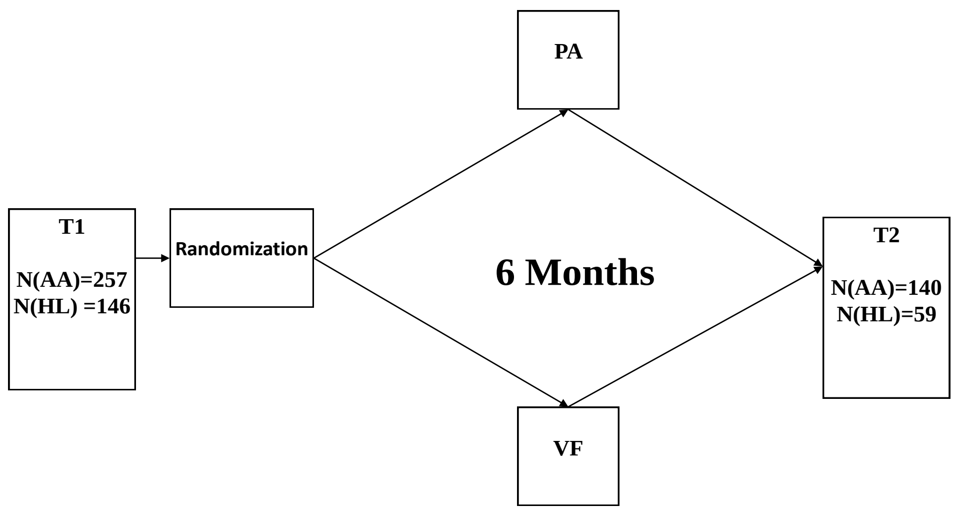

Figure 3: HIP Project Procedures (T1-T2)

First, **Research Question 1** will address the following:

Research Question 1: What is the strength and direction of the concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women?

> Research Question 1.1: What is the strength and direction of the concordance between directly and indirectly measured **physical activity resource (PAR) accessibility** among separate samples of AA and HL women?
>
> Research Question 1.2: What is the strength and direction of the concordance between directly and indirectly measured **sidewalk maintenance** among separate samples of AA and HL women?
>
> Research Question 1.3: What is the strength and direction of the concordance between directly and indirectly measured **pedestrian facility density** among separate samples of AA and HL women?
>
> Research Question 1.4: What is the strength and direction of the concordance between directly and indirectly measured **bicycle facility density** among separate samples of AA and HL women?

The purpose of **Research Question 1** is to measure the strength and direction of the concordance of directly and indirectly measured built environment attributes among/in AA and HL women. Few data exist examining the concordance between the two types of measurement and strong concordance of direct and indirect built environment measurement could provide fewer measurement inconsistencies and stronger built environment measurement concordance (i.e. fewer misperceptions about the built environment). No built environment concordance data exist among AA and HL women. Further, because health attitudes and behaviors can vary by ethnicity (Gordon-Larsen, McMurray and Popkin,1999; Harris, Walters and Waschull,1991; Stern et al.,1982), examining concordance among both AA and HL women is necessary and could provide additional information as to how concordance can vary among two different groups of ethnic women. Last, existing data demonstrate significant inconsistencies among direct and indirectly measured built environment attributes (Foster & Giles-Corti, 2008; Gebel et al., 2009; McGinn et al., 2007). **Research Question 1** may provide greater insight as to the relationship between built environment attributes and perceptions of built environment attributes. Assessing misperceptions of the built environment is important for several reasons. Built environment misperceptions have been associated with lower levels of PA and other health behaviors (Gebel et al., 2009). Further, addressing and correcting residents' misperceptions through community education and increased signage could increase PA among residents. For example, if neighborhood residents don't think many parks are within close proximity of their home, they might do less PA. Educating residents on the presence, amenities and quality of PARs could increase PAR use and possibly PA. Further, exploring these associations in AA and HL women could demonstrate significant associations between concordance and PA for populations that are at risk for physical inactivity and obesity. These relationships will be explored at University of Houston's (UH) Texas Obesity Research Center (TORC).

Next, **Research Question 2** will address the following:

Research Question 2: What are the correlates of the concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women?

Research Question 2.1: How are body fat percentage, BMI and PA associated with the concordance between directly and indirectly measured **physical activity resource (PAR) accessibility** among separate samples of AA and HL women?

Research Question 2.2: How are body fat percentage, BMI and PA associated with the concordance between directly and indirectly measured **sidewalk maintenance** among separate samples of AA and HL women?

Research Question 2.3: How are body fat percentage, BMI and PA associated with the concordance between directly and indirectly measured **pedestrian facility density** among separate samples of AA and HL women?

Research Question 2.4: How are body fat percentage, BMI and PA associated with the concordance between directly and indirectly measured **bicycle facility density** among separate samples of AA and HL women?

The purpose of **Research Question 2** is to examine the correlates of the concordance of directly and indirectly measured built environment attributes among/in AA and HL women. Investigating specific correlates (i.e. body fat, BMI and PA) is important when measuring concordance between the direct and indirect built environment measures. Correlates can affect the direction and strength of the concordance by affecting perceptions (i.e. indirectly measured built environment attributes) and decreasing the concordance between direct and indirectly measured data (Gebel et al., 2009). Like perceptions of the built environment, these correlates could also differ by population and affect measurement concordance. For example, a severely obese individual may have less knowledge about her neighborhood PARs because she doesn't leave her home. Or a resident might be extensively familiar with her neighborhood PARs because she coaches local sports teams and is very physically active. These correlates are necessary to address and investigate when measuring the concordance of direct and indirect built environment attribute measurement. Although few studies have examined the concordance between direct and indirect built environment measures, even fewer data exist investigating the correlates of concordance of direct and indirect built environment measurement.

The following variables will be correlated with the concordance of the direct and indirectly measured built environment attributes: body fat percentage, BMI and objectively measured and self-reported PA. Self-reported PA is assessed using interview-administered questionnaires. Because self-reported PA has been associated with neighborhood perceptions (Boehmer et al., 2006; Catlin, Simoes, & Brownson, 2003; Humpel et al., 2002), we will correlate self-reported PA to the concordance of direct and indirectly measured built environment attributes. Because age and socioeconomic status have been associated with body fat percentage, BMI and PA (Flegal et al., 2002; USDHHS, 1996; Bauman, Owen and Rushworth, 1990), these variables will also be included as covariates in the analyses. Further, investigating these correlates of the concordance could address why specific built environment non-concordances (i.e. neighborhood misperceptions) exist. Also, if specific correlates of the concordance of directly and indirectly measured attributes are found, methods to address and mend misperceptions of the built environment can be employed. For example, if BMI is a strong, negative correlate of a strong, positive concordance of direct and indirectly measured built environment attributes, we would know that more overweight or obese residents have more misperceptions about their neighborhood resources. Knowing that a specific correlate exists and the direction and strength of its relationship to the concordance of the built environment attributes can provide meaningful implications for residents. Specific methods and education techniques can be employed to raise awareness of built environment resources for specific populations (e.g., obese, sedentary) possibly increasing their PA and overall health. These relationships will be explored at University of Houston's (UH) Texas Obesity Research Center (TORC) and derived from the ongoing HIP Project as described in the Methodology.

Last, the following **Hypothesis 1** will be tested:

Hypothesis 1: The degree of concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women will be associated with greater PA adoption from time 1 (baseline) to time 2 (post intervention).

Hypothesis 1.1: A higher degree of concordance between directly and indirectly measured **PAR accessibility** among separate samples of AA and HL women will be associated with greater PA adoption from Time 1 to Time 2.

Hypothesis 1.2: A higher degree of concordance between directly and indirectly measured **sidewalk maintenance** among separate samples of AA and HL women will be associated with greater PA adoption from Time 1 to Time 2.

Hypothesis 1.3: A higher degree of concordance between directly and indirectly measured **pedestrian facility density** among separate samples of AA and HL women will be associated with greater PA adoption from Time 1 to Time 2.

Hypothesis 1.4: A higher degree of concordance between directly and indirectly measured **bicycle facility density** among separate samples of AA and HL women will be associated with greater PA adoption from Time 1 to Time 2.

Outline

A global representation of the detail provided within this dissertation follows.

Chapter 1, Introduction, introduces the topic for this thesis. It also is a guide for the chapters that will follow.

Chapter 2, Literature Review, explains the current research available on the topic and points out limitations in the current knowledge. It further establishes the inconsistencies between direct and indirect built environment measurement concordance, possible correlates of measurement concordance and how these measures could be related to PA adoption. Upon reading this chapter the reader should understand the purpose for the investigation topic.

Chapter 3, MANUSCRIPT: CONCORDANCE AND CORRELATES OF DIRECT AND INDIRECT BUILT ENVIRONMENT MEASUREMENT, will fully describe the planned methodology for Research Question 1 and Research Question 2 in this thesis. Here direct and indirect built environment data will be correlated among separate samples of AA and HL women. The strength and direction of these correlations will be measured to assess concordance. Next, body fat, BMI and PA (along with age and socioeconomic status) will be associated with the concordance of directly and indirectly measured built environment attributes.

Chapter 4, MANUSCRIPT: CORREPONDENCE OF DIRECTLY AND INDIRECTLY MEAUSRED BUILT ENVIRONMENT ATTRIBUTES AND PHYSICAL ACTIVITY ADOPTION will fully describe the planned methodology for Hypothesis 1 in this thesis. Here the degree of concordance between directly and indirectly measured built environment attributes among separate samples of AA and HL women will be associated with PA adoption from Time 1 (baseline) to Time 2 (post intervention).

Potential Contributions

Knowing whether direct and indirectly measured built environment attributes concord, whether body fat, BMI and PA are correlates of their concordance and if their concordance (or non-concordance) is related to PA adoption can: 1) address inconsistencies and answer questions about the relationships between the built environment and perceptions about the built environment, 2) determine whether accurate perceptions are important for PA adoption and 3) provide meaningful data for understudied populations for whom no similar data exist.

Although the bulk of this dissertation is based on research investigating the built environment measurement and PA adoption, there are potential benefits for individuals. If our hypotheses are supported, residents whose built environment perceptions are more similar to actual built environment attributes (i.e. exhibit fewer misperceptions and a stronger concordance) will display higher levels of PA adoption. If these associations exist, implications for improving PA adoption among AA and HL women could be made.

Further, if these associations differ by ethnic samples, ethnic-specific implications could be made. Greater familiarity with one's environment may provide greater incentive to be physically active in it, especially among those who live in supportive neighborhoods. These communities, in particular, could promote built environment attributes in an attempt to increase PA adoption. Or, if a built environment is poor in quality or has few resources for PA, greater familiarity with ones environment might deter PA adoption. Regardless of the direction, strength and significant correlates of these associations, their investigation is essential among the vulnerable population of minority women in which no study of this kind exists. These relationships will be thoroughly explored in this dissertation and important implications for obesity prevention and treatment could result.

Definitions of Important Terms and Abbreviations

AA: African American

HL: Hispanic or Latina

PA: Physical Activity

PAR: Physical Activity Resource

TORC: Texas Obesity Research Center

HIP: Health is Power

UH: University of Houston

CHAPTER 2

LITERATURE REVIEW

Introduction

This critical literature review is intended to present a detailed overview of the current knowledge related to the concordance between directly and indirectly measured built environment attributes, correlates of this concordance and PA adoption for African American (AA) and Hispanic or Latina (HL) women. No research investigating built environment measurement concordance, its correlates and PA adoption among AA and HL women has been conducted to date; however, research related to the purpose of this proposal is presented. The information provided will allow the reader to gain an understanding for the importance of conducting the proposed research. I will critically review literature in the following domains: 1) Ecologic models and the importance of the built environment, 2) direct built environment measurement, 3) indirect built environment measurement, 4) concordance of direct and indirect built environment measurement 5) correlates of concordance of direct and indirect built environment measurement 6) PA adoption among AA and HL women and 7) the relationship among direct and indirectly measured built environment attributes and PA.

PAR accessibility, **sidewalk maintenance, pedestrian facility density** and **bicycle facility density** will be addressed in all built environment measurement sections. In addition, the importance of studying AA and HL women will be discussed in the PA adoption section. A brief overview of what has been learned for built environment measurement concordance as related to PA is also described.

In order to discuss the methodology for the proposed experiment, it is important to understand Ecologic models and both direct and indirect built environment measurement. Specifics and examples of PARs, pedestrian and bicycle facilities, direct and indirect measurement, as well as typical terminology used to describe built environment measurement and attributes will be discussed in all sections. Some of the prominent direct and indirect measures for the built environment are also included. With a foundation for understanding direct and indirect built environment measurement, we extend this understanding to apply it to built environment measurement concordance and correlates of this concordance.

In this proposal, built environment assessments are used to explore direct and indirect built environment measurement concordance. Most built environment measurement concordance research reveals significant inconsistencies among direct and indirect measures (Foster & Giles-Corti, 2008; Gebel et al., 2009; McGinn, Evenson, Herring, Huston et al., 2007). These inconsistencies are discussed as related to PARs, pedestrian facility and bikeway environment measures. Using the knowledge available for direct and indirect built environment measurement concordance, three specific correlates (i.e. BMI, body fat and PA) of the built environment measurement concordance will be explored.

Last, since this proposal investigates built environment measurement concordance and its association with PA adoption among AA and HL women, a review of PA adoption as related to built environment measurement concordance is included. Here the literature from each section will also be summarized and connected with the overall purpose of the study: how directly measured built environment attributes relates to indirectly measured environmental perceptions and how attribute concordance relates to PA adoption among minority women.

The Ecologic Model and the Importance of the Built Environment

Ecologic models suggest that individual, social and environmental factors (e.g., the presence and quality of PARs) are interrelated and associated with various health behaviors like PA (Sallis et al., 1998; Sallis and Owen, N., 1997; Spence, 2003). Ecological models also incorporate interdependent intra- and extra-individual influences that may influence individual behaviors at multiple levels (Sallis and Owen, N., 1997; Spence, 2003) and provide researchers with innovative opportunities for health interventions. Intra-individual influences include factors like gender, race and health attitudes. Earlier research has examined the association between these types of intra-individual influences and PA (Sallis, 1992; Sherwood, 2000; Giles-Corti, 2002) but fewer studies have associated attitudes about extra-individual influences with PA. Extra-individual influences include environmental factors like transportation systems, goods and services and physical activity resources (PARs). In particular, an obesogenic environment encourages excessive caloric consumption and physical inactivity (Swinburn, 1999) and includes macro-, exo-, meso- and micro-environmental dimensions (Egger, 1997; Lee & Cubbin, 2009; Spence, 2003) (See Figure 1).

The microsystem are the settings where individuals interact and include homes, work, parks and schools (e.g., PARs). The mesosystem contains the interactions between two or more microsystems and the exosystem is composed of the linkages and processes between two or more microsystems with at least one microsystem that doesn’t typically involve the individual. The macrosystem encompasses the meso-, exo- and microsystem dimensions and is the larger sociocultural context (Spence, 2003). Earlier studies have provided a close examination of these settings and revealed associations between the environment and physical activity, dietary habits and obesity prevalence in its encompassing residents (Heinrich et al., 2008; Rabin, 2007).

In conjunction with an obesogenic environment, intra-individual influences, like SES, ethnicity and gender, can also significantly affect environmental perceptions and health behaviors (Annesi, 2007; Gordon-Larsen, Adair, & Popkin, 2002; Sallis, Hovell, & Hofstetter, 1992). In particular, built environment perceptions and the concordance of built environment perceptions and actual built environment attributes have been significantly associated with PA (Gebel et al., 2009; Humpel, 2004). Based on the theoretical framework of the Ecological Model of Physical Activity (Figure 1), Built Environment Measurement among AA and HL women (Figure 2) is presented in Chapter 4.

Figure 2 suggests that, in conjunction with other intra-individual factors like ethnicity and gender, the strength and direction of the concordance of directly and indirectly measured built environment attributes might be affected by correlates such as BMI, PA and body fat and may be associated with PA adoption. For example, an AA female may reside in a low SES neighborhood with few or no free-to-use PARs (i.e. accessible PARs). Because she has recently walked in and around her neighborhood, she also correctly perceives this lack of few or no free-to-use PARs (i.e. demonstrating a strong concordance of directly and indirectly measured PAR accessibility). But, because she is aware of her limited PA environment and knows that her ethnicity is more prone to obesity, she chooses to buy a piece of home exercise equipment and adopts a regular PA program. Although she is limited by her local built environment, she is aware of these limitations (i.e. demonstrating a strong concordance of directly and indirectly measured PAR accessibility) and knows her ethnic vulnerability to obesity and its comorbidities, so she decides to adopt PA, regardless of the lack of accessible PARs in her neighborhood.

Another example might be a HL mother of four who lives in a neighborhood with a high number of pedestrian facilities, although she strongly disagrees that "there are many sidewalks on most of her streets" (i.e. demonstrating a weak concordance of directly and indirectly measured pedestrian facility density). Further, because her ethnic and cultural background may influence her to always prepare home-cooked meals and be present when her family arrives home from school or work, she may not have the opportunity to explore her neighborhood after she leaves her own job. Because she perceives that there are few pedestrian facilities and because she values this cultural belief based on her ethnicity, she chooses to not explore her PA options and remains sedentary. These two examples demonstrate the interrelation of individual, social and built environment factors, based on Ecological models, and their contribution to neighborhood residents' PA adoption. (See Figure 2.)

Although this dissertation will investigate the concordance of directly and indirectly measured built environment attributes and associate this relationship with PA adoption (as displayed in Figure 2), intra-individual factors can also be significant influences of PA adoption (Annesi, 2007; Gordon-Larsen et al., 2002) and will be measured as covariates (BMI, body fat and PA) and included as covariates in analyses.

Direct Built Environment Measurement

Neighborhood built environments can be measured directly (using objective field assessments) or measured indirectly (using self-report questionnaires). Direct built environment measurement involves two main types of assessments: Geographical Information Systems (GIS) and objective field assessments. For the purposes of this dissertation, only objective field assessments will be discussed as our primary measure of built environment attributes.

Audit Tools. Objective field assessments are audit tools that allow for systematic observation of the built environment, including the presence and qualities of neighborhood attributes hypothesized to affect PA and other health behaviors (e.g., PARs and sidewalks). Researchers can also use audit tools to collect direct data on built environment attributes that are not commonly included within GIS databases (e.g., PAR quality, sidewalk maintenance and width). Also, audit tools can be used to measure physical features that are best assessed through direct observation (e.g., bicycle lane designation, signage, aesthetic quality) (Clifton, 2007; Lee et al., 2005).

Audit tools typically require in-person observation for collecting data. Researchers walk or drive through a neighborhood (i.e. windshield) and assess area features (e.g., parks, sidewalks, bicycle lanes), systematically coding characteristics using objective definitions and a standardized form. The audit tool can be a paper form with close-ended questions or sections (e.g., check boxes, Likert scales) and can sometimes include open-ended questions or written comments (e.g., extended hours, future visit times). Specific neighborhood features like street segments are usually sampled within a pre-defined region. Although some investigators choose to purposefully sample important features of the environment, such as parks or arterial street segments, most sampling is random. Researchers can usually not directly measure all neighborhood resources and segments, with some exceptions (e.g., Lee et al., 2005). Additional specific types of built environment measures will be discussed in future sections.

Time Required. Planning and conducting direct built environment measurement is usually very time-consuming. Researchers must select and/or sample neighborhoods and their resources, define and sample segments within neighborhoods, train and supervise data collectors, collect data, enter and proof data, and compute and score raw data into usable variables. These steps can be very involved and technical in nature. Time required for data collection varies, depending on the number of items observed and the type of environment (e.g., mixed use or residential only). Because of the time involved, researchers should consider whether direct observation is absolutely necessary for testing hypotheses or whether existing data (e.g., local GIS data) would appropriately answer the research question(s).

Auditor Training. Relevant skills that are needed for directly measuring the built environment include some knowledge of the content area (e.g., urban planning, recreation studies) as well as the ability to appropriately perform the protocol of the chosen audit tool. Typically, observers are undergraduate or graduate research assistants from different fields (e.g., public health, social science, kinesiology, urban planning), who are trained to observe detailed features of the environment. Classroom training (using an illustrated reference manual) and training sessions in the field are usually mandatory before observers can collect data. Training and practice can occur in teams and/or individually, but to initially practice measuring and/or coding features and to discuss results, a team leader is usually required. Because many terms and concepts are likely to be unfamiliar to observers (e.g., PAR accessibility, pedestrian facility), the manual and training must provide clear definitions (preferably with clear illustrations and examples). Observers should be trained until they demonstrate high concordances with their trainer and/or team leader, and inter-observer reliability should be monitored throughout the study to ensure validity and reliability of the audit tool(s).

Which Audit Tool(s) to Use? Selecting from among the available audit tools requires careful consideration, especially for neighborhood assessments. Numerous options exist, depending upon the researcher's goals. Researchers should consider factors such as areas and attributes observed, available staff, time required for data collection, data entry and proofing, coding and scoring, sampling (e.g., all street segments versus a sample), how to manage aggregate data, instrument validity and reliability, and the ability to compare results with other findings (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009).

Directly-Measured Physical Activity Resources (PARs).

Several direct PAR assessment tools have emerged in recent years. PAR assessment tools enable researchers to directly measure recreation facilities designed for PA (Brownson et al., 2004; Cerin, Saelens, Sallis, & Frank, 2006; Lee et al., 2005). The most commonly-used direct PAR assessment tools have been extensively tested and peer reviewed (Clifton, 2007; Lee et al., 2005).

Direct PAR measures provide objective data and strong evidence for policy change impacting urban planning and transportation (significant correlates of adopting and maintaining PA). PARs can be measured using direct in-field assessments that provide important neighborhood qualitative and quantitative data. Using direct measures, PAR attributes can be objectively defined and rated by field assessors based on independent definitions for each attribute's existence and/or a quality rating (Lee et al., 2005).

PAR attributes and neighborhood disparities. Directly-measured PAR attributes have been significantly associated with PA (Heinrich et al., 2007; Lee et al., 2005) and have been associated with race (Powell, 2006) and SES (Estabrooks, 2003; Wolch, 2005). Consistent evidence suggests that PAR attribute inequalities helps to explain racial/ethnic and income disparities in PA and obesity (Gorden-Larsen, 2006 and Powell, 2006). Other studies indicate that public spending on parks and open spaces is lower in low-income communities of color as compared to more affluent, higher-income areas (Wolch, 2005).

A related concern that affects the quality of PARs is the concept of "deprivation amplification". Deprivation amplification refers to places where people have fewer personal resources and the local facilities that enable people to lead healthy lives are poorer economically compared to areas that are not impoverished and socially deprived (Macintyre & Ellaway, 2000). Both built environmental social justice principles and deprivation amplification are relevant frameworks for directly measuring PARs and comparing attributes to indirect PAR data.

For example, PAR accessibility, a measure of whether a facility is free or pay for use, can significantly affect PA (Heinrich et al., 2007). Evidence consistently demonstrates racial and ethnic disparities in access to PARs (Gordon-Larsen, Nelson, Page, & Popkin, 2006; Moore, Diez Roux, Evenson, McGinn, & Brines, 2008; Powell, Slater, Chaloupka, 2004; Wolch, 2005). Estabrooks found that low- and medium- SES neighborhoods had significantly fewer free-for-use resources than did high-SES neighborhoods (2003). Another PAR attribute that can vary by neighborhood is a PAR incivility (e.g. vandalism, litter, unattended dogs, etc.). Incivilities have been used to describe the quality and social order of a neighborhood (Scahfer, 1999 and Airey, 2003) and their presence at PARs has been associated with higher BMIs (Heinrich et al., 2008). In addition, concerns about neighborhood incivilities may be barriers for performing PA in low-income communities of color (Boslaugh, Luke, Brownson, Naleid, & Kreuter, 2004). Objectively-measured PAR amenities and features have also been associated with BMI in ethnic minorities (Heinrich et al., 2008). PAR amenities are additional resource conveniences (e.g., bathrooms, picnic tables, lighting), whereas features are facilities used for primarily PA (e.g., exercise stations, swimming pool, soccer field) (Lee et al., 2005). PAR attributes can be directly measured and have been significantly associated with PA.

Directly-Measured Pedestrian Facilities

Pedestrian Facilities and PA. Like PARs, pedestrian facilities (e.g., sidewalks, walking trails) are significant domains of the built environment and have been associated with PA, specifically moderate PA adoption (Giles-Corti and Donovan, 2003; Lopez, Bryant, & McDermott, 2008). These associations are especially significant for sedentary populations as evidence suggests that performing regular moderate-intensity activity provides health benefits similar to those accrued from vigorous activity (Blair et al., 1996; Pate et al., 1995; USDHHS, 1996).

Walking is the most popular form of PA and most people who walk do so in their neighborhood (Moudon et al., 2007; Reis, Macera, Ainsworth, & Hipp, 2008) and can be performed with little or no equipment. Moderate levels of PA, like walking, have become a major focus of many PA interventions and new policy initiatives in recent years (Bauman, Sallis, Dzewaltowski, & Owen, 2002; Sallis et al., 1998). Giles-Corti found that the quality of the walking environment may be more important than the SES of the area of residence and, as a correlate, has the potential to influence participation in both walking and vigorous activity (2002). Although moderate PA adoption and walking are emphasized among built environment and PA- related studies, pedestrian facilities and their attributes have been significantly associated with various types of PA (Cerin, Leslie, & Owen, 2009; Giles-Corti, Donovan, 2003; Moudon et al., 2007) and various health outcomes (Leslie et al., 2007).

Direct Pedestrian Facility Measurement. To directly measure pedestrian facilities, street segment is the typical unit of observation. Segments are usually comprised of two facing sides of one street block. Segments are typically sampled within a given area. Although sampling protocols vary, it is dependent upon the researcher's question(s) and chosen methodology.

To directly measure a pedestrian facility on a street segment, the best pedestrian facility is chosen by the trained assessor(s). Several attributes can be directly measured (e.g., width, connections, quality, etc.) based on the audit tool's objective definitions (Clifton, 2007). Sidewalk maintenance can be assessed based on the amount of debris and/or the overall condition of the facility. For example, the Pedestrian Environmental Data Scan (PEDS) instrument protocol (Clifton, 2007) allows auditors to choose from the following conditions when assessing sidewalk maintenance:

Path Condition/Maintenance:

- Poor (many bumps, cracks, holes and weeds)
- Fair (some bumps, cracks, holes and weeds)
- Good (very few bumps, cracks, holes and weeds)
- Under Repair

Auditors choose one option based on the overall quality of the facility. Variables are coded and scored for data analyses. Another extensively studied pedestrian facility attribute is density. Pedestrian facility density is the number of pedestrian facilities within any given predefined neighborhood. Most areas are predefined based on the questions for investigation. Based on earlier findings, an investigator might predefine a region (i.e. neighborhood) as an 800m radius circle encompassing a resident's address (Lee et al., 2005; Lee, et al., 2003). Defining neighborhoods as this region captures all areas to which a resident may be exposed to on a daily basis both on foot and vehicle (Lee, et al., 2003). Pedestrian facility density would then be the number of sidewalks and/or pathways within this 800m radius circle.

Directly-Measured Bicycle Facilities

Bicycle Facilities and PA. Cycling is a physically active and environmentally friendly means of transport. Health educators and researchers continue to recognize the many health benefits of cycling (Byrne, 2009; Dunn et al., 1999; Oja, Vuori, & Paronen, 1998). Cycling is also more sustainable mode of PA and an effective means of PA for currently sedentary people.

Many short distance trips and commutes can be traveled by bicycle. For example, in the U.S., 40% of total auto trips are shorter than 2 miles (Transportation, 2004). Despite these close proximities, cycling shares less than 1% of commuting trips (Pucher, 1999).

The lack of cycling for transportation could stem from several issues. Cycling is often viewed as exercise or recreation and is dependent on age and gender. More males report cycling than females and younger people are more likely to cycle than older people (State Transportation Statistics, 2004). Although many built environments lack bicycle lanes and other cycling facilities, investments in non-motorized safety and infrastructure make-up an extremely small portion of transportation budgets (Tri-State Transportation Campaign, 2000)

Although the health benefits of cycling are well documented and recognized, a comprehensive understanding of the associations among built environment attributes (e.g., the presence of designated bicycle lanes, specific bicycle routes) and cycling is lacking (Moudon et al., 2005). Several studies have investigated the effects of bicycle facility attributes on motorized travel and various types of PA, but less attention has been give to how these characteristics affect PA adoption.

Direct Bicycle Facility Measurement. Several audit tools have been developed to capture the bikability of built environment, yet the validity and reliability remains insufficiently tested (Moudon & Lee, 2003). In order to directly measure bicycle facilities, auditors can assess specific attributes like path condition, type of surface material and degree of enclosure. Although some built environment and cycling research focuses on perceived barriers of cycling (i.e. indirect measured attributes), actual bicycle facility attributes attributes (i.e. direct measures) are also relevant to PA levels (Goldsmith, 1992; Litman, 2000).

A bicycle facility can include a number of directly measureable attributes. For example, Clifton defines a bicycle facility as one or more of the following (2007):

- A bicycle route sign
- A striped bicycle land designation
- Visible bicycle parking facilities (rack, etc)
- Bicycle crossing warning

Bicycle facility density is the number of bikeways for any given segment and/or neighborhood (Clifton, 2007). Although, the presence of bicycle facilities has not been clearly associated with an increase in cycling for neighborhood residents, the lack of adequate direct bicycle facility measures could be to blame. Also, the potential role of related land use and urban planning, developed to increase cycling, has often been overlooked or remains difficult to assess (Cervero, 2003). Assessing bicycle facility denisty might provide additional insight for these unknowns and be related to perceptions of bicycle facility density.

Indirect Built Environment Measurement

Neighborhood built environments can also be measured indirectly (using self-report questionnaires). Most evidence on the association between built environment attributes and PA is derived from indirect self-report data (i.e. residents' perceptions of their environments) (Gebel, Bauman, & Petticrew, 2007; Humpel, Owen, & Leslie, 2002) as compared to directly measured data. According to Gebel and colleagues, over 100 studies have examined PA behavior as related to perceptions of the environment (2009) and these studies defined environment as a combination of the following: the built (i.e. physical) environment and policy influences (Brownson, Baker, Housemann, Brennan, &

Bacak, 2001; Rutten, 2001; Sharpe, 2004). For the purposes of this dissertation, indirect self-reported data collection will be discussed.

Self-reported questionnaires. Indirect measures of the built environment include self-reported data on perceived environmental attributes. Data are collected by interviewers via telephone and in-person or by self-administered questionnaires by mail or email. Most self-reported data are collected as part of a larger research project (Brownson et al., 2009). Other national organizations, like the CDC, have also used surveillance systems (i.e. Behavioral Risk Factor Surveillance System) (Center for Disease Control and Prevention, 2009a) so that individual responses can be aggregated and neighborhood attributes can be identified geographically, by population and/or longitudinally (Brownson et al., 2009).

Content and Format. The format of indirect built environment questionnaires can vary yet most tools are developed based on similar fundamental frameworks. A recent paper by Brownson et al. comprehensively reviewed several popular self-reported built environment measures (2009). Because there are numerous published studies assessing and investigating self-reported environmental attributes (Gebel, 2009), the authors chose to review 15 popular instruments used with adults and 4 instruments used with children. All chosen questionnaires covered a variety of populations, administration modes and content (Brownson et al., 2009). The most commonly used tool internationally was the Neighborhood Environment Walkability Scale (NEWS) (Saelens, Sallis, Black, & Chen, 2003) and most tools explored several different aspects of the built environment as based on theoretical models (Brownson et al., 2009). The development of indirect tools as based on theoretical models is especially important as most models have been extensively studied and peer-reviewed.

For example, Pikora et al identified four important environmental domains to be measured (2003): functional, safety, aesthetic and destination (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003). This conceptual framework has been used to guide the creation and progression of self-reported questionnaires (Brownson et al., 2009). Brennan Ramirez et al. added to this framework by using a five-phase expert review process, including a larger focus on policy-related variables in order to identify indicators of supportive environments (Brennan Ramirez et al., 2006). Although the format of most indirect built environment questionnaires varies, the underlying theoretical framework remains consistent among measures (Brownson et al, 2009).

Challenges and Guidelines. Regardless of the mode of administration chosen, self-reported questionnaires can present many challenges to researchers. A common problem with using indirect measures can be the declining response rates. Response rates can also decrease with longer measures (Biner, 1994). For this reason, researchers are advised to choose the survey that is as short as possible yet measures what is needed for the investigation (Brownson et al., 2009). Further, personal perceptions of the built environment are often indirectly linked to objectively measured attributes (St. John, 1987). For example, individual perceptions often stem from chosen directly measured built environment attributes that are based on past experiences, aspiration levels, adaptation methods and individual characteristics (St. John, 1987). (i.e., two different individuals living in the same neighborhood can perceive their built environment very differently. Last, some data suggest that source (i.e. the individual responding to the questionnaire) bias may exist, furthering hindering accurate perceptions of ones neighborhood (Mujahid, Diez Roux, Morenoff, & Raghunathan, 2007). These perceptions can also vary, depending upon the specific built environment attributes being measured (e.g., PARs, pedestrian facilities, bicycle facilities).

Indirectly-Measured Physical Activity Resources (PARs)

Indirectly Measured PAR Attributes and PA. PARs are indirectly measured using self-reported questionnaires. Indirect, self-reported measures of the built environment have been associated with PA levels (Velasquez, Holahan, & You, 2009), and can also vary by individual and neighborhood (Hoehner, Brennan-Ramirez, Elliot, Handy, Brownson, 2005; Velasquez et al., 2009). Further, perceptions of PAR attributes like amenities and features may foster different types and levels of PA. Velasquez found that perceptions of neighborhood characteristics were related to PA and to meeting PA recommendations, with stronger associations for women than for men (2009). Hoehner et al. found that urban adults who perceived their neighborhood to have more attractive features were more likely to engage in recommended recreational PA (2005).

Associations among indirectly-measured PAR attributes and PA can also differ depending upon the specific PAR attribute being measured. Boslaugh et al. found that both individual and neighborhood characteristics were significant predictors of how individuals perceived PA opportunities in their neighborhood, and that AA perceived their neighborhoods as less safe and less pleasant for PA than did whites, regardless of the racial composition of the neighborhood (Boslaugh et al., 2004).

Indirectly-Measured PAR Accessibility. Other indirectly-measured PAR attributes like PAR accessibility have been associated with PA for other populations. For example, Hoehner et al. reported that perceived access to recreational facilities was associated with recreational activity (2005) (Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson, 2005). Further, low-income women have perceived a lack of access to PA in their community as a major factor inhibiting the development of healthy lifestyles for themselves and their families (Frisby, 1997). Another study found that few perceived measures of recreational facilities were associated with obesity (Boehmer, Hoehner, Deshpande, Brennan Ramirez, & Brownson, 2007). Perceived recreational facility access also differed by gender in the obese vs. normal weight comparison and lack of equipment was stronger among women. Perceived access also differed by income level in the obese/inactive vs. normal weight/active comparison suggesting that the lack of equipment and many places to recreate were stronger within the lower-income group (Boehmer et al., 2007). These results suggest that indirectly-measured PAR attributes, specifically PAR accessibility, are significantly associated with PA. Although these are significant findings related to PA, no evidence suggests how indirectly-measured PAR accessibility relates to directly-measured PAR accessibility for ethnic minority women, a group most vulnerable to physical inactivity or how this concordance is related to PA.

Indirectly Measured Pedestrian Facilities

Indirectly-measured pedestrian facility density is the self-reported or perceived number of pedestrian facilities in a local neighborhood. Like indirectly-measured PAR attributes, perceptions can vary by population and geographic location, suggesting that individual factors can influence measurement. For example, the obese may be more likely to perceive that no sidewalks exist in their neighborhood (Boehmer et al., 2007). McGinn et al. found that associations between perceptions of having places to walk differed between study sites from two states (North Carolina and Mississippi) (2007).

Perceptions of pedestrian facility density differ by population and geographic locations and have also been significantly associated with PA.

Indirectly-Measured Pedestrian Facilities and PA. Like directly-measured PAR attributes, indirectly-measured pedestrian facilities (e.g., sidewalks, walking trails) attributes have been significantly associated with PA (Corti, 1997; Wright, 1996). Neighborhood residents who perceive there to be more pedestrian facilities available (i.e. perceive a higher pedestrian facility density) are more likely to be physically active (Corti et al., 1997). Aesthetic features, such as the presence of trees and greenery, are also important for PA (Corti et al., 1997) as attractiveness of streetscape has been associated with walking (Sallis and Owen, 1997). Another study found that the perceptions that "there are many interesting things to look at while walking" was significantly associated with higher levels of leisure-time PA in men but not in women (Bengoechea, 2005). Known walking routes and safety of trails from crime has also associated with regular walking behavior (Granner et al., 2007). Although indirectly-measured pedestrian facility attributes can significantly affect PA, they could differ from actual pedestrian facility attributes and this association could affect PA adoption.

Indirectly Measured Bicycle Facilities

Like PARs and pedestrian facilities, bicycle facility attributes can also be indirectly measured. Self-report questionnaires are used to assess individual perceptions about specific variables of interest as related to cycling. Some questionnaires include questions assessing perceptions of bicycle facility attributes like bicycle facility density, One common indirect bikeway assessment question assessing bicycle facility density is the IPS (Sallis, 2002) environmental survey module. Like other indirect measures, this tool assesses neighborhood perceptions about specific built environment attributes. To indirectly assess bicycle facility density, the following question is used:

There are facilities to bicycle in or near my neighborhood, such as special lanes, separate paths or trails, shared use paths for cycles and pedestrians. Would you say that you…

Strongly disagree
Somewhat disagree
Somewhat agree
Strongly agree
Does not apply to my neighborhood
Don't know/Not sure

The IPS and other popular indirect built environment measures commonly assess bikeway density as their perceived presence has been associated with various forms and levels of PA (Hoehner et al., 2005).

Indirectly measured bicycle facility attributes and PA. Like directly-measured bicycle facilities, indirectly-measured bicycle facility attributes are important determinants of PA. Although bicycle facilities are far less studied as compared to PARs and pedestrian facilities, perceptions of access and visibility have shown to be associated with various forms of PA. For example, Hoehner found that transportation activity was positively associated with perceived access to bike lanes (2005) and Harkey et al. found that a provision of a wide bicycle lane or paved shoulder and on-street parking increased the perceived comfort of cyclists (1998).

Like pedestrian facilities, indirectly measured bicycle facility attributes vary by population and geographic location. Titze found that cycling was negatively associated with the perceived barriers, "physical discomfort" and "impracticable transport" in Austria (Titze, Stronegger, Janschitz, & Oja, 2008). Yet, in the U.S., Moudon et al. found that the perception of neighborhood traffic problems and automobile-oriented facilities were only moderately significant, suggesting that cycling largely takes place irrespective of environmental prompts or barriers, and independently from traffic conditions (2005). Although there are far fewer studies that have indirectly measured bicycle facility density, perceptions of this built environment attribute are important to measure as the relationship between directly and indirectly measured bicycle facility density could be significantly associated with PA adoption.

Concordance of Direct and Indirect Built Environment Measurement

Built environment measurement concordance is the correlation between direct and indirect assessments of the built environment. Concordance is measured by the strength and direction of the correlation between directly measured and indirectly measured variables of the built environment. For example, if a resident perceives that her neighborhood has high PAR accessibility (i.e., there are many free PARs to use) and directly-measured data (i.e. objective assessments) suggest that there is, in fact, high PAR accessibility for her neighborhood, a strong and positive concordance exists for PAR accessibility. But if a resident perceives that her neighborhood has no PAR accessibility (i.e. there are no free PARs to use) and directly-measured data suggest that there is medium PAR accessibility (i.e. ~50% of PARs are accessible), a weak and negative concordance exists for PAR accessibility.

Built Environment Concordance and PA. Although perceived and objective measures of the built environment have been associated with PA (Boehmer et al., 2007), less is known about how built environment measurement concordance relates to PA adoption. Gebel et al. found that there was a fair overall agreement between objectively determined walkability and perceived walkability, thus creating potential for PA promotion and persuasion strategies to address non-concordance (2009). Humpel also showed that when adults' perceptions of the environment improved as related to PA (with no actual change of the environment), they were significantly more likely to increase their walking (2004). No known study has associated directly and indirectly measured concordance with PA adoption or PA adoption among minority women.

In order to provide a comprehensive built environment attribute concordance literature review, attributes from three different aspects of the built environment will be discussed: PARs, pedestrian facilities and bicycle facilities.

Concordance of Direct and Indirect PAR Attributes.

PAR attributes can be directly and indirectly measured, yet few studies have systematically measured the concordance of directly and indirectly measured PAR attributes. For example, independent from one another, directly and indirectly measured PAR accessibility, are both commonly assessed built environment attributes (Estabrooks, 2003, Heinrich et al., 2008, Frisby, 1997 and Boehmer, 2007), has been associated with PA. Yet, few studies have compared objective and perceived PAR accessibility. Scott et al. found that the number of recreational facilities within a half-mile of girls' homes strongly predicted the perception of easy access to seven out of nine recreational facility types, suggesting that directly measured PAR data was associated with indirectly measured PAR data (2007). Hoehner et al. found that perceptions of more recreational facilities were significantly associated with some types of recreational PA, yet non-significant associations were made between perceptions of recreational facilities and audit data (derived from direct measures) (2005). Further, a more recent study found that self-reports of tennis courts were poorly correlated with objective data (Ball et al., 2008). These low correlations were generally consistent with those of previous studies (Kirtland et al., 2003; McGinn, Evenson, Herring, Huston et al., 2007; Troped et al., 2001). Ball et al. suggests that “studies that rely on self-report perceptions as an indicator of the actual environment may incorrectly estimate the true associations between physical environments and PA” (2008). Last, McCormack et al. examined the concordance between perceived and objectively determined accessibility to various destinations and found poor agreement between distance measures (2008). Low correlations between directly and indirectly measured PAR attributes are common findings.

Why are there low correlations of directly and indirectly measured PAR attributes? Researchers suggest that misperceptions can explain the low correlations of PAR attributes. Women, children, and long-term residents may perceive their neighborhood as a smaller place than others (Guest, 1984) as do immigrants and individuals of lower SES (Sastry, 2002). How people perceive their neighborhood can also be associated with their own personal lifestyles, health states, behaviors and attitudes (Boehmer et al., 2007; Cho, Rodriguez, & Khattak, 2009; Gebel et al., 2009; McGinn, Evenson, Herring, & Huston, 2007). Also, mode of transportation can affect PAR attribute perceptions. How people travel to work can expose them to different aspects of the built environment at different times and rates. For example, someone who walks to work may be more familiar with PARs located in route to their job as compared to someone who drives to work. Further, physically active people may be more familiar with PARs and their attributes because they use them.

The concordance of directly and indirectly measured PAR attributes is complex and not well understood. Few studies have investigated PAR accessibility concordance and none have investigated this relationship among ethnic minority women.

Concordance of Direct and Indirect Pedestrian Facility Attributes

Trail use. Little data exist for the concordance of directly and indirectly measured pedestrian facility attributes. Among the few studies that exist for the concordance of pedestrian facility attributes, some have assessed trail use. Troped et al found that the mean values for self-report and GIS network distances from a trail were significantly correlated with each other. Also, the percentage of adults with a busy street barrier was about the same between perceived and GIS variables (Troped et al., 2001). Further, Brownson and colleagues found that rural trail users were willing to travel great distances to access a trail, suggesting that perceptions of trail proximity may vary by the type of built environment conditions in various residential settings (Brownson et al., 2004). These associations are complex and as Abildso and colleagues suggest, there is “a lack of consensus regarding the nature of the relationship among objective and perceived environmental assessments and trail use” (Abildso, Zizzi, Abildso, Steele, & Gordon, 2007).

Other Pedestrian Facilities. Although findings are limited, some data exist for other types of pedestrian facility attribute concordance. Ball et al. found that self-reports of walking/bicycling tracks located about 2 km from a participant’s home (i.e., 15–20 min walk or 5 min drive) were poorly correlated with objective data among Australian women (Ball et al., 2008). Conversely, Leslie and colleagues found that perceived neighborhood characteristics were significantly related to objectively assessed ‘walkability’ (2007). Although the authors did not measure direct concordance of pedestrian facility attributes, there were statistically significant differences in residents' ratings of environment characteristics. Those living in objectively 'high'-walkable areas significantly differed than those living in 'low'-walkable areas for density, street connectivity and infrastructure for walking (all $p<0.001$). Their results suggest that residents from neighborhoods with different features perceive these attributes differently (Leslie et al. 2005).

Few studies exist examining the relationship between directly and indirectly measured pedestrian facility attributes. Most of studies that do exist have measured trail attribute concordance. No known data exist for the concordance of directly and indirectly measured pedestrian facility density among minority women.

Concordance of Direct and Indirect Bicycle Facility Attributes

Built environment concordance literature is limited, and even fewer studies have measured the relationship between directly and indirectly measured bicycle facility attributes. Bicycling is a popular means of transport and recreational activity (Herlihy, 2004), so measuring the concordance bicycle facility attributes could provide significant implications for PA adoption. Further, there has been little public health research examining factors that influence recreational and transport-related cycling environmental measurement.

One recent study examined objective neighborhood data and perceived safety risks associated with cycling. Although this study did not study the exact concordance of bicycle facility attributes, Cho et al. found that residents who live in low density-single residential neighborhoods are more likely to perceive their neighborhood as dangerous for cycling relative to residents of compact, mixed-use neighborhoods (2009).

Interestingly, residents of compact, mixed-use neighborhoods exhibited higher actual cycling crash rates (Cho et al., 2009).

Similar to other built environment attribute concordance literature, data are severely limited for bicycle facility attribute concordance. No known study has measured the concordance of directly and indirectly measured bicycle facility density. More investigation is needed.

In the next section, other variables (i.e. correlates) that can influence the concordance of direct and indirectly measured built environment attributes will be discussed, including: body fat percentage, BMI and PA.

Correlates of the Concordance of Direct and Indirect Built Environment Measurement

It is well known that understanding the correlates of PA is essential when developing evidence-based interventions (Bauman et al., 2002; Sallis et al., 1999; Sallis, 1999) and an increasing number of studies are identifying built environment attributes as correlates of PA (Boehmer et al., 2007; Gebel et al., 2009; McGinn, Evenson, Herring, Huston et al., 2007). Less is known about correlates of the concordance of directly and indirectly measured built environment attributes.

Correlates of concordance (e.g., body fat percentage, BMI, PA) can affect the strength and direction of the concordance of direct and indirect built environment measurement (Boehmer et al., 2007; Gebel et al., 2009; McGinn, Evenson, Herring, Huston et al., 2007). In other words, perceptions of the built environment can vary depending upon body fat percentage, BMI and/or PA levels. Because individual perceptions can vary, correlates are often considered when measuring built environment attribute concordance. For the purposes of this dissertation, three correlates will be measured and associated with the concordance of directly and indirectly measured built environment attributes: body fat percentage, BMI and PA. PA will be self-reported and objectively measured. These correlates have all been associated with direct **or** indirect built environment attributes (Handy, Boarnet, Ewing, & Killingsworth, 2002; McGinn, Evenson, Herring, Huston et al., 2007; Saelens, Sallis, & Frank, 2003), but few studies have systematically associated these correlates with the concordance of direct and indirect built environment attributes.

Further, the relationships between PA and directly and indirectly measured built environments have varied depending upon the measure of PA (i.e. self-reported vs. objectively measured). Because of these variances, both self-reported and objectively measured PA will be associated to built environment attribute concordance.

Measuring body fat percentage, BMI and PA and associating these correlates to the concordance of directly and indirectly measured built environment attributes can demonstrate variations of concordance (i.e. variations of built environment perceptions) and could provide further insight into increasing PA adoption. A discussion of each correlate follows.

BMI

To classify weight status, researchers and clinicians use Body Mass Index (BMI) (CDC, 2009). BMI is a proportion of weight to height in a mathematical formula. Normal weight (i.e., healthy weight) is defined as a BMI between 18.5 kg/m^2 and 24.9 kg/m^2. Under weight (i.e., a weight where there is not enough weight for good health) is a BMI falling below 18.5 kg/m^2. Overweight (a weight that is too much for good health) is a BMI between 25 kg/m^2 and 29.9 kg/m^2. A BMI that meets or exceeds 30 kg/m^2 indicates obesity and is too much weight for good health. Obese weight status is divided into three classes. Class 1 obesity is defined by a BMI between 30 kg/m^2 and 34.9 kg/m^2 and Class 2 obesity is defined by a BMI between 35 kg/m^2 and 39.9 kg/m^2. Class 3 obesity (i.e., morbid obesity) is defined as a BMI at or above 40 and is defined as a signficant health risk and too much weight for the body to survive in good health (Center for Disease Control and Prevention, 2009b).

BMI as a Correlate of Concordance. Some studies suggest that obese persons tend to misperceive their built environments more so than normal weight persons, demonstrating a mismatch of attribute concordance. Obesity is assessed using BMI (CDC, 2009) and earlier studies have used BMI to measure weight status to be used as a correlate of the concordance of objective and perceived built environment attributes (Boehmer et al., 2007; Gebel et al., 2009). Gebel et al. showed that those who were overweight were more likely to misperceive a high-walkable environment as low than those at a healthy weight (2009). Another study found that obese and persons were twice as likely to report having no nonresidential destinations within a 10–min walk than their normal weight counterparts (Boehmer et al., 2007). In the same study, obese persons were also over 2-times more likely to disagree that there were sidewalks present on most streets (Boehmer et al., 2007). These data suggest that built environment attribute concordance could vary based on BMI. The authors suggest that BMI could be a significant correlate of concordance because overweight and/or obese persons might be less physically active than those of normal weight (Boehmer et al., 2007), but more study is needed.

How is BMI measured? BMI uses height and weight in a mathematical formula using pounds and inches or kilograms and meters. Height can be measured using a statiometer and weight can be measured using a standard scale. The participant's height and weight is imputed into one of the following formulas:

$$\textbf{BMI} = \frac{\textbf{(weight in pounds * 703)}}{\textbf{height in inches}^2} \quad (\textbf{kg/m}^2)$$

$$\textbf{BMI} = \frac{\textbf{weight in kilograms}}{\textbf{height in meters}^2} \quad (\textbf{kg/m}^2)$$

Why BMI? Researchers often use BMI as a measure of weight status because it allows for a larger number of participants and can be measured fairly quickly. Some studies only use BMI as a measure of body composition and/or weight status because other measures of body composition (e.g., waist circumference, body fat percentage, anthropometric measurements) can take much longer. Also, unlike other measures of weight status or body composition, BMI is less invasive. For example, skinfold measurements (used to measure body fat percentage) require participants to expose limbs and raise their shirts. This and other methods can be far less private than BMI. BMI is also inexpensive and does not require much training.

Limitations of BMI. One major limitation of BMI is that it doesn't directly measure body fat percentage (Gallagher et al., 1996). Because of this limitation, persons with a high BMI, like athletes, may be classified as overweight or obese, when in fact, they have much more muscle mass than the average person and a low body fat percentage. Another limitation has recently been discovered. Jackson et al. found that

BMI underestimated adiposity in Asian and Mexican women and overestimated adiposity in African American women (2009). Because of these variations among BMI results, body fat percentage will also be measured as a correlate of the concordance between directly and indirectly measured built environment attributes.

Body Fat Percentage

Along with BMI, researchers will often assess participants' body fat percentages. A person's total body fat percentage is the total weight of the person's fat divided by the person's weight and includes essential fat and storage fat. Essential fat is that amount of fat necessary for bodily and reproductive functions. Storage fat consists of fat accumulation in adipose tissue and includes fat that protects internal organs. Although BMI is used more often, body fat percentage is the only body composition measurement that directly calculates an individual's body composition without considering an individual's BMI (i.e. height and weight). Body fat percentage is most commonly assessed using Bioelectrical Impedance Analysis.

Bioelectrical Impedance Analysis. Bioelectrical Impedance Analysis (BIA) is a quick, relatively inexpensive and noninvasive method of measuring body fat percentage. BIA is the passing of a small electric current throughout the body and the measurement of the impedance to that current (Kaminsky, Wang, & Petronis, 2006). Data has shown it to be an accurate method of measuring body composition in children (Houtkooper, 1996). BIA can be used as a hand-to hand device or a foot-to-foot scale device. Like BMI, BIA is commonly used in studies with large numbers of participants, because it doesn't require extensive training, can be done quickly, and is relatively private for participants. One drawback of BIA is that it requires that participants follow preparatory guidelines to avoid biasing results. The most common guideline, proper hydration, is especially necessary for impedence measurement (Heyward, 2004).

Along with BMI and body fat percentage, it is also important to measure participants' activity levels when assessing possible correlates of the concordance of directly and indirectly measured built environment attributes. Both self-reported and objectively measured PA can influence built environment perceptions and contribute to the concordance (or nonconcordance) of directly and indirectly measured built environment attributes. PA and both self-reported and objectively measured PA are discussed in the next section.

PA

Several studies have investigated the associations between PA and directly measured built environment attributes or PA and indirectly measured built environment attributes. Research suggests that it is important to use both perceived and objective measures of environmental attributes, as each can relate to PA differently (Boehmer, Lovegreen, Haire-Joshu, & Brownson, 2006; McCormack et al., 2008; McGinn, Evenson, Herring, Huston et al., 2007). For instance, a study that used a combination of perceived and objective measures of the built environment found that both types of measured attributes were differentially associated with PA levels (McGinn, Evenson, Herring, Huston et al., 2007). Also, several studies suggest that direct neighborhood data is associated with PA types and levels (Handy et al., 2002; Heinrich, 2007; Parks, 2003; Saelens, Sallis, Black et al., 2003; Zlot & Schmid, 2005). The relationships between directly measured built environment attributes and PA will be discussed further in a future section.

PA and Indirectly Measured Built Environment Attributes. In recent years, an increasing number of studies have examined the relationship between perceptions of built environment attributes and PA. For example, several studies suggest that perceptions of recreational facility access are strongly associated with PA behavior and obesity (Boehmer et al., 2006; Catlin, Simoes, & Brownson, 2003; Humpel et al., 2002). Evenson et al. examined girls' neighborhood perceptions and found that having well-lit streets at night, having "a lot of traffic" in the neighborhood, having bicycle or walking trails in the neighborhood and access to PARs were associated with higher MET-weighted moderate-to-vigorous PA levels (2007).

One recent PA intervention targeted older adults and found that those whose environmental perceptions were targeted had significantly higher levels of cycling as compared to a group whose psychosocial determinants of PA were targeted (Stralen van, 2008). Another study examining cycling neighborhood attributes suggested that that active respondents (i.e. participants with higher PA levels) may have been more likely to perceive recreational facilities or bike lanes as accessible (Kirtland et al., 2003). Further, Humpel and associates found that changes in perceptions of environmental attributes increased walking. The study found that men whose perceptions of environmental aesthetics and convenience of access to destinations became more positive were more than twice as likely to have increased their walking levels. Women whose perceptions of convenient access to destinations became more positive were more than twice as likely to increase their walking. This study's results suggest that assessing perceptions of neighborhood attributes is important when measuring the built environment as it relates to PA, and improving perceptions of attributes could increase walking levels (Humpel et al., 2004).

Although researchers have begun to establish the importance of neighborhood perceptions and PA, few studies have examined PA as a possible correlate of built environment attribute measurement concordance. Of these few studies, none has examined objectively measured PA as a possible correlate of concordance. Only self-reported PA has been studied as a possible correlate. For the purposes of this dissertation critical literature review, both objectively measured PA and self-reported PA will be discussed. Since no previous study has examined objectively measured PA as a possible correlate of concordance, there is no literature to review for this section. Only self-reported PA will be discussed as a correlate of the concordance between directly and indirectly measured built environment attributes.

Self-reported PA as a Correlate of Concordance. The existing data demonstrating PA as a correlate of concordance have only measured PA using self-report methods. A recent study found that higher self-reported walking times were noted among participants who lived in a neighborhood with low walkability that was perceived as high walkability, compared to those who lived in a high walkable environment that was perceived as low walkable. These results suggest that adults who were less physically active for transportation purposes were more likely to misperceive their high walkable neighborhood as low walkable (Gebel et al., 2009). Another study examining BMI and PA as correlates of perceived and actual neighborhood attributes found that obese/inactive persons were twice as likely to report having no nonresidential destinations within a 10–min walk than their normal weight counterparts (Boehmer et al., 2007). These results suggest that the combination of PA and BMI could demonstrate different built environment attribute agreement patterns (Boehmer et al., 2007). Other researchers investigating perceived and actual bicycle safety risks suggest that the association between neighborhood perceived safety risk and the number of reported walking trips taken by participants could help determine whether avoidance behaviors (i.e. not cycling) exist (Cho et al., 2009).

One Australian study examined the concordance between perceived and objectively measured accessibility of different destinations. The agreement between perceived and objective measures of distances was poor and different levels of agreement existed between men and women, residents of different neighborhood types, and for different walking levels (McCormack et al., 2008). Another recent Australian study analyzed agreement between perceptions and objective audits of access to various local PARs among women. The concordance between the two measures was relatively low and differed by age, income, self-efficacy for PA, PA levels, and length of residency in the neighborhood (Ball et al., 2008).

Not all built environment attribute concordance studies have found PA as a significant correlate. McIntyre examined the concordance between perceptions and GIS measures of accessibility to public parks and found poor agreement, but there were no differences in agreement by reported behavioral characteristics (Macintyre, Macdonald, & Ellaway, 2008). These results suggest that the strength and direction of PA as a correlate of concordance can vary. In order to adequately define and review PA as a possible concordance of directly and indirectly measured built environment attributes, the next section will discuss the meaning of PA and how it is measured.

Benefits, Recommendations and Prevalence. PA is any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level (Caspersen, Powell, & Christenson, 1985). In conjunction with the CDC guidelines, PA generally refers to the subset of human movement that enhances health (Centers for Disease Control and Prevention, 2009). Regular PA is important for good health and especially important for weight loss and maintenance (Lee et al., 2010). Consistent evidence demonstrates that the only way to maintain weight loss is to be engaged in regular PA (Anderson, Konz, Frederich, & Wood, 2001; Pronk & Wing, 1994; Tate, Jeffery, Sherwood, & Wing, 2007; USDHHS, 1996). PA helps to maintain weight, reduce high blood pressure, reduce risk for type 2 diabetes, heart attack, stroke, and several forms of cancer. PA also reduces risks of cardiovascular disease and diabetes beyond that produced by weight reduction alone. Moderate intensity PA is associated with numerous health benefits, including a lower all-cause mortality, lower cardiovascular mortality, improved function, and enhanced quality of life. Further, vigorous-intensity activities (such as running and other aerobic sports) that challenge the cardiovascular system are strongly related to many positive health outcomes (Centers for Disease Control and Prevention, 2009).

Several organizations and agencies have supported health-related recommendations of 30 minutes per day of moderate-intensity physical activities on most days of the week (Pate et al., 1995; NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996) but most Americans do not achieve these recommended amounts (Macera, 2005). Macera found that only 45% of adults were active at recommended levels during nonworking hours (2005). They defined active is engaging in at least 30 minutes of moderate-intensity activities five or more days per week (equivalent to brisk walking five or more days per week), or at least 20 minutes three or more days per week in vigorous activities (equivalent to running, heavy yard work, or aerobic dance) (2005). Their study revealed that the majority of U.S. adults were not active at levels associated with the promotion and maintenance of health (Macera, 2005). More recent revisions to the 1996 guidelines suggest that a minimum of 150 minutes of moderate physical activity or 75 minutes of vigorous physical activity should be done weekly, along with strength training (Centers for Disease Control and Prevention, 2009). These latest guidelines also suggest that more benefits can be gained by increasing the recommended amount.

PA Measurement. There are several techniques for the assessment of PA and all can be grouped into the following general categories: behavioral observation, questionnaires (including diaries, self-reported questionnaires and interviews), and objective physiologic measures like heart rate, calorimetry, and motion sensors (Westerterp, 2009). In order to validate different and new assessments of PA, more study is always needed, but measuring the interrelation of various field methods can cause errors, making it is sometimes impossible to determine the true validity of any particular one. For the purposes of this dissertation literature review, objective accelerometry PA measures and self-reported questionnaires will be discussed as measures of PA.

Accelerometry-measured PA. An accelerometer is a sensing element that measures the rate of change of velocity with respect to time (i.e. acceleration). Accelerometers measure in units of g (i.e., the acceleration measurement for gravity or 9.81m/s ^2) and can measure vibrations, shocks, tilt, impacts and motion of an object

(Westerterp, 2009). Accelerometers are used to evaluate PA intensity and duration and are based on the measurement of human body movement. They cannot be used to measure the static factor of certain exercises like weight lifting or carrying certain loads, but the only the dynamic component of daily PA. In order to validate accelerometer measured PA, energy expenditure can be measured by direct or indirect calorimtery (e.g., doubly labeled water method, chamber).

There are several types of accelerometers available (i.e., single axis and multiple axis accelerometers) to use. Plasqui and Westerterp evaluated eight different accelerometers and used doubly labeled water as a reference (2007) and found that the best results were found for the Tracmor (Philips Research, Eindhoven, The Netherlands), a device with the first published doubly labeled water validation (Bouten, Verboeket-van de Venne, Westerterp, Verduin, & Janssen, 1996). The device will be commercially available soon (Westerterp, 2009).

Strengths. Because of its many strengths, accelerometers are often used as objectively measurements of PA (Westerterp, 2009). Accelerometers can continuously record PA information over user-specified time intervals (e.g., 5s, 15s, 30s, 1min, etc.) and can provide information about the total amount, the frequency, the intensity, and the duration of PA. PA intensity levels (i.e., METs, MPA, MVPA) can be computed using the accelerometer generated output and age-specific PA intensity cut-points. Further, accelerometers place less burden (e.g., time, attention, staff) on researchers as compared to direct observation or interview administered questionnaires. They also provide much more detailed and accurate information (e.g. intensity, estimated calorie expenditure) as compared to questionnaires. Accelerometers can also store real time data, which is a distinct advantage over self-report questionnaires.

Limitations. Accelerometers have many strengths but also have several limitations. They do not provide qualitative information about the type of activity being performed, and the accuracy of the accelerometer is dependent on the activity mode. For example, there is little concordance between accelerometry and energy expenditure during movements with static hip position (e.g. lifting objects and cycling). Studies suggest that the best concordance between accelerometry and energy expenditure is made when measuring walking activities (Jakicic et al., 1999; Trost et al., 1998). Further, accelerometers ($350-500) are typically more expensive than using self-reported methods. Using accelerometers in larger studies often depends on the financial means to purchase large numbers of them and the availability of personnel and equipment used to process and analyze their output and data. Accelerometers can also require external computer hardware (i.e., interface equipment) and software to analyze PA results.

Technical concerns can also exist. For example, choosing and setting intensity cut-points and time sampling intervals requires extensive knowledge of accelerometers and equipment training. Several practicality issues can also be weaknesses (e.g., distribution and collection, protocol, lost devices) (Slootmaker, Schuit, Chinapaw, Seidell, & van Mechelen, 2009). All of these issues must be considered before using accelerometers. Researchers should establish a standardized accelerometer data collection procedure for collecting valid and comparable measures of PA for their sample(s).

Self-Reported PA Questionnaires. Self-reported questionnaires can also be used as an adequate measure of PA. Self-reported PA questionnaires are surveys assessing various aspects of daily human movement (i.e. daily PA) and can be interview-administered (i.e., a researcher can read the questions aloud to participants) or self-administered (i.e., participants read the questions themselves). These surveys typically ask respondents about the types of PA they engage in as well as the intensity, frequency, and duration of these activities over a specified amount of time. For the purposes of this dissertation literature review, self-reported questionnaires include interview-administered and self-administered questionnaires.

Strengths. Self-reported questionnaires are the most common tools for assessing PA (Sallis & Saelens, 2000) and are often used because of their many strengths. The methodology is cheaper than objective measures and allows for application in large populations. Unlike other objective PA measures, they do not alter behavior of participants and can assess all elements of PA. They can also be used on a wide range of populations, because questionnaires can be adapted to fit the needs of certain populations and research questions. In general, interview measures also have stronger psychometric characteristics than self-administered measures (Sallis & Saelens, 2000).

Limitations. Numerous limitations of self-reports have been discussed and investigated (Ainsworth, Jacobs, & Leon, 1993; Ainsworth et al., 2006; Ainsworth, Richardson, Jacobs, Leon, & Sternfeld, 1999; Sallis & Saelens, 2000). Overreporting of PA is cited as a common limitation (Buchowski, Townsend, Chen, Acra, & Sun, 1999; McMurray et al., 2004; Timperio, Salmon, & Crawford, 2003). For example, Warnecke and colleagues found that social desirability bias lead to the over-reporting of PA (Warnecke et al., 1997). Further, other data suggest that psychosocial variables can affect PA recall (Jago, Baranowski, Baranowski, Cullen, & Thompson, 2007). Recalling PA can be a challenging and difficult cognitive task, and some questionnaires are more difficult to comprehend than others. Participants must be familiar with the broad term of "physical activity" and share the same understanding of this definition with researchers. Further, other PA terms like "intensity" and "transportation PA" can be misleading and misunderstood.

Last, self-report questionnaires may not validly measure PA for certain gender, age, cultural, occupational, or income groups (Sallis & Saelens, 2000; Shephard, 2003). Some data from self-reported PA measures have been shown to report differences between gender and ethnic subgroups compared to accelerometers (Sallis, Bauman, & Pratt, 1998). Other studies have shown agreement between objective and self-report methods. For example, data from self-report assessment of PA have consistently found that women are less physically active than men, overweight subjects are less active than normal weight subjects, and adults are less active than adolescents (Buchowski et al., 1999; Caspersen, Pereira, & Curran, 2000; Gordon-Larsen et al., 2002; Sallis & Saelens, 2000). Other studies using objective assessment of PA (i.e. accelerometry) confirm these findings (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008; Troiano et al., 2008; Trost, Kerr, Ward, & Pate, 2001).

PA is a complex health behavior and as a possible correlate of the concordance between directly and indirectly measured built environment attributes, it is important to understand investigate. Although most individuals are familiar with the benefits of regular PA, overall PA levels are low and could be associated with perceptions of the built environment. Results from studies investigating PA can often depend on whether objective or self-report assessments were used. There are strengths and limitations for both types of tools and researchers should be aware of these issues when choosing PA measures.

PA Adoption

Although the benefits of adopting PA are publicized (Centers for Disease Control and Prevention, 2009; USDHHS, 1996), recent data shows that rates of physical inactivity are high, particularly among minority women (Kruger et al., 2008). Because physical inactivity is a major risk factor for many diseases, health research efforts are examining means of increasing PA. Researchers have theorized that becoming physically active consists of four main phases: adoption, maintenance, relapse and resumption (Dunn, 1996). Systematic research of why people begin PA is becoming increasingly important as investigators and clinicians shift from treatment of disease to prevention of disease. The first phase, adoption, is the focus of this section.

PA adoption is an essential component for a healthy lifestyle and treatment. PA adoption can help to prevent cancer, obesity and other health compromising conditions. PA adoption is the beginning or initiation of PA without regard to the maintenance of that PA (Sherwood & Jeffery, 2000). Although many studies have examined determinants of PA maintenance or PA adherence, less empirical evidence examining PA adoption exists, particularly for highly vulnerable populations.

Investigating why people adopt PA is theoretically complex yet necessary to improve PA levels. The Surgeon General has suggested that theoretical models are most salient for explaining PA behavior and for the designing of interventions to promote PA (USDHHS, 1996). For this section, personal characteristics associated with PA adoption will be discussed as related to psychosocial constructs and social-cognitive theories (i.e., Transtheoretical model (TTM) (Bandura, 1986; Prochaska, 1982) and Social Cognitive

Theory (SCT) (Bandura, 1986).

Personal Characteristics associated with PA Adoption. Why people begin PA is associated with their personal characteristics and current lifestyle. Personalities and habits can help to initiate PA but can vary by individual. Motivation, self-efficacy, stage of change, exercise history, body weight, health risk profiles, diet and health have been shown to be associated with PA adoption and will be discussed in the following sections.

Motivation. One of the most important determinants of PA adoption is why people decide to initially perform PA or the motivation of PA adoption. Earlier studies suggest that overall health, appearance, recreation, social interaction, stress relief and achievement are just a few of the top reasons for engaging in regular PA (Frederick, 1993; Nies, Buffington, Cowan, & Hepworth, 1998) but less is known as to why individuals adopt PA. The motivation to participate in PA can differ by gender (Biddle, 1985; Caspersen, 1990) and can influence the mode of PA chosen (Frederick, 1993). Also, individuals may adopt PA to avoid the negative aspects of physical inactivity. One study reported that some people are more motivated to exercise by the desire to avoid unpleasant aspects of a sedentary lifestyle than they are by focusing on the enjoyable aspects of exercise (King, Taylor, Haskell, & DeBusk, 1990).

Self-Efficacy. Among the psychological correlates of exercise that have been examined, self efficacy is the strongest and most consistent predictor of exercise behavior (Brawley, 1993; Courneya & McAuley, 1993). Self-efficacy is an individual's belief in her capability of performing necessary action(s) to satisfy situational demands (Sherwood & Jeffery, 2000). Further, as an attempt to assess self-efficacy as related to PA, exercise self-efficacy is often used. Exercise self-efficacy is the degree of confidence an individual has in his/her ability to be physically active under a number of specific/different circumstances or able to overcome barriers of exercise (DuCharme & Brawley, 1995). Some data suggest that self-efficacy is particularly important in the early stages of exercise (McAuley, 1992).

The importance of self-efficacy for initiating and maintaining a pattern of regular PA stems from social–cognitive theories of behavior (Bandura, 1977). Further, numerous studies have revealed a consistent positive relation between exercise self-efficacy and stages of change (Marcus et al., 1992; Marcus, Pinto, Simkin, Audrain, & Taylor, 1994; Nigg & Courneya, 1998).

Stage of Change: The Transtheoretical model (TTM). Successful PA promotion interventions have been based on the TTM (Bauman, Owen, & Rushworth, 1990). Although the TTM emerged from psychotherapy to treat addictive behaviors, it has been translated into an underlying framework to understand PA adoption (Baranowski, Anderson, & Carmack, 1998). Several reviews have investigated TTM as an application for understanding PA and many strengths were noted (Bauman et al., 1990; Biddle, 1985; Blair, 1985).

For example, TTM views change as a dynamic and moving through a series of five stages as categorized by a “readiness” to change. These stages depend on the individual’s intention and behavior and are labeled as follows:

1. Precontemplation (no intention of becoming physically active

2. Contemplation (thinking about starting to become physically active within the next 6 months)

3. Preparation (making small changes in behavior but still not meeting a criterion for PA)

4. Action (meeting a criterion of PA, but only recently—usually within the past 6 months)

5. Maintenance (meeting a criterion for PA for 6 months or longer).

(Prochaska & DiClemente, 2005)

Although the original theoretical model proposed that individuals moved linearly through the stages (Bandura, 1986) scholars now recognize that individuals are more likely to move through each stage in a cyclical pattern (Blair et al., 1996). In an effort to maintain PA, individuals progress and regress among all stages. Some studies suggest that validated measures of PA have been able to differentiate between stages (Bouchard, 1994; Brawley LR, 1993; Cardinal & Sachs, 1996) but other measures used to classify individuals into various stages have varied (Carpenter et al., 1999) and other studies have compared PA levels across collapsed stages (Brawley, 1993; Carron, 1996). Despite these findings, three factors mediate the change process:

1. An individual's self-efficacy for change
2. The decisional balance of perceived advantages (e.g. increased health, longer lifespan) and disadvantages of change (less leisure time, muscle soreness).
3. The strategies and techniques (the processes of change) individuals use to modify their thoughts, feelings, and behavior.

(Bandura, 1986)

Empirical evidence examining these mediators varies. As mentioned in the prior section, self-efficacy has shown to be the strongest and most consistent predictor of behavior change. The decisional balance of perceived advantages and disadvantages of change can be more complex. Marshall and Biddle found that a variety of cognitive and motivational factors (e.g., pros and cons of decisional balance) can exist as an individual changes stages (2001). In particular, when examining PA adoption, Lippke and Plotnikoff found that perceived severity and vulnerability were significant factors (2006). Further, Dunton and Vaughan suggest that knowing whether anticipated affective consequences of success and failure vary across stages and differentially predict behavior adoption as compared to maintenance (2008). Processes of change can also vary by individual. For example, Marshall et al. found that the pattern (i.e. process) of change for behavioral processes from their results significantly differed from earlier studies (2001). Although Marshall and colleagues hypothesized that behavioral processes would increase up to the stage of Action and then level off during the Maintenance stage, Precontemplation to Contemplation and Preparation to Action demonstrated sharper increases in behavioral process as compared to other stage transitions (2001). More study is needed to fully comprehend how these stage change mediators vary and how they modify individuals' thoughts and feelings towards PA adoption.

Exercise History. Data suggest that exercise history can also positively influence PA adoption by promoting exercise self efficacy and developing PA skills (Dishman, 1994), but the observed relationship between exercise history and exercise behavior can depend on how exercise history is defined (Sherwood and Jefferey, 2000). While positive influences of exercise history are common for adults, childhood exercise history is inconsistently related to adult PA (Hoftstetter, 1990; Hovell et al., 1989). For example, one study found that childhood PA experiences were only modestly predictive of adult self-efficacy and exercise behavior (Hoftstetter, 1990). Another study found that “recalling being forced and/or encouraged to exercise as a child” was associated with lower levels of adult PA (Taylor, Blair, Cummings, Wun, & Malina, 1999).

Other Health Behaviors. Another significant determinant of PA adoption is an individual’s health behavior profile. Relationships between PA and other health behaviors such as smoking, diet and stress can affect whether one adopts PA. Some data suggest that the strongest correlates of PA are smoking and diet. Although results can vary (Johnson, Nichols, Sallis, Calfas, & Hovell, 1998), smokers are found to be less likely to lead physically active lifestyles than nonsmokers (Blair, 1985; Emmons, Marcus, Linnan, Rossi, & Abrams, 1994; Sallis et al., 1992; Tang et al., 1997) and are also less likely to adopt PA (Hooper & Veneziano, 1995). In regards to diet, active adults generally report eating healthier diets than do sedentary adults. Although chronic moderate-level exercise is associated with increased energy consumption (Blair et al., 1981), physically active adults tend to eat diets lower in fat compared with inactive adults (Hovell et al., 1991; Hovell et al., 1989). Some evidence suggests that this relationship might also vary according to body weight (King, 1991). Further, high levels of stress may be associated with lower levels of PA (Allison, Adlaf, Ialomiteanu, & Rehm, 1999). Although perceived stress has the greatest impact on exercise behavior (Aldana, Sutton, Jacobson, & Quirk, 1996), evidence suggests that those who engage in higher levels of PA report lower levels of perceived stress (Aldana et al., 1996). The authors propose that planned PA may be a minor stressor during periods of ongoing stress and understanding of the dynamic relationships between stress and PA adoption might help individuals cope with barriers to PA (e.g., lack of time, equipment, etc.) (Aldana et al.,1996).

PA Adoption Among Minority Women. Although they often report that they are interested in increasing their exercise (Hsieh, Novielli, Diamond, & Cheruva, 2001), women demonstrate higher sedentary rates as compared to men (Macera, 2005). Among women, older women and minority women generally have consistently showed the lowest physically active rates of any community group (Booth, Owen, Bauman, Clavisi, & Leslie, 2000; Brownson et al., 2000; Scharff, Homan, Kreuter, & Brennan, 1999; Weiss, O'Loughlin, Platt, & Paradis, 2007). Further, research suggests that factors influencing PA are different for men and women, and there may be different factors influencing PA adoption versus maintenance of vigorous PA (Sallis, Hovell, & Hofstetter, 1992).

For example, a large study comparing four racial/ethnic groups of women (AA, White, Hispanic, Asian) found that AA women reported the lowest rates of performing recommended levels of regular PA (Brownson et al., 2000). Also, a larger proportion of AA women reported no leisure time PA as compared to White or Hispanic women. Other similar studies have shown lower PA levels for AA women for other types of PA like household and occupational PA (Ainsworth, Irwin, Addy, Whitt, & Stolarcyzk, 1999; Sternfeld, Ainsworth, & Quesenberry, 1999). Although these studies can provide some insight as to how much or even why minority women do not participate in PA, less is known about how and why minority women adopt PA.

Many studies have attempted to verify the pathways to PA adoption through the application of existing theoretical frameworks (e.g., TTM and SCT), but most of them have focused on explaining variation in PA levels (King, Stokols, Talen, Brassington, & Killingsworth, 2002). Even those that have found support for existing behavioral theories (i.e., TTM) have not been focused on illustrating the behavioral process of PA adoption (Harley et al., 2009). More study is needed to explore PA adoption, particularly among minority women.

PA Adoption and the Built Environment

Since the adoption of PA is key to the prevention of weight gain and numerous cancers, studies that investigate built environment measurement factors related to the adoption of PA are extremely important. Ecological and social-ecological models of human behavior have evolved over decades in the fields of sociology, psychology and public health (Green, Richard, & Potvin, 1996) and their significance to PA is now widely recognized (Breslow, 1996; McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis et al., 1998). For example, built environmental changes can benefit all people in a surrounding neighborhood rather than only focusing on changing the behavior of one person at a time. Also, built environment changes can be more permanent than interventions focusing on individual-level change (e.g., playgrounds, sidewalks).

Most of the evidence for techniques that help inactive people to adopt PA result from quasi-experimental and experimental intervention studies examining individual cognitive and behavioural strategies (Dunn, 1996; Marcus et al., 2000). Less research has examined PA adoption techniques at the community and environmental level. Although most first generation studies examining the association between built environmental attributes and PA were limited to recreational PA, more recent studies examining other types of PA (e.g., moderate, vigorous, transportation) have emerged. Also, built environmental approaches can provide opportunities, support, and cues to help people adopt PA and complement individual level-programs. Empirical evidence consistently supports these associations (Sallis and Owen, 1997, Sallis, Bauman et al., 1998, Spence and Lee, 2003, Heinrich et al., 2008), but less is known about how built environment attributes affect PA adoption, in particular. Most data examining the relationships between built environment attributes and PA are focused on other aspects of PA behaviors (e.g., maintenance, adherence, frequency of bouts). Even fewer of these studies investigate these relationships among the highly inactive population of minority women. For the purposes of this dissertation critical literature review, this section will discuss the following built environment attributes as related to PA adoption: physical activity resource (PAR) accessibility, sidewalk maintenance, pedestrian facility density and bicycle facility density.

Physical Activity Resource (PAR) Accessibility and PA Adoption. Although the literature examining PA adoption as related to built environment studies is limited as compared to other types and stages of PA, PAR accessibility is the often studied. For example, one study by Matson-Koffman et al. examined policy and environmental strategies that promoted PA and healthy nutrition. The authors found that access to places and opportunities for PA (including access to exercise facilities) provided the strongest evidence for influencing PA promotion and healthy eating (Matson-Koffman, Brownstein, Neiner, & Greaney, 2005). These results suggested that PAR accessibility successfully promoted PA and similar strategies could increase PA adoption for other communities. One review of 19 studies demonstrated consistent associations of accessibility of recreational facilities, opportunities to be active with PA in adults. In their review, Humpel et al. found that accessibility of facilities and opportunities for PA (i.e., programs) demonstrated significant associations with PA (2002). Another review emphasized that neighborhood facilities were popular locations to perform PA (Lee, 2004) and Owen et al. found that walking for recreation was repeatedly associated with the convenience of facilities (2004). Although several studies examined the associations between PAR accessibility and PA behaviors, fewer studies specifically examine these relationships with PA adoption.

Sidewalk Maintenance and PA Adoption. Like PAR accessibility and PA adoption, few studies exist examining sidewalk maintenance as related to PA adoption. Two studies found that pedestrian facilities (e.g., sidewalks, walking trails) were significantly associated with moderate PA adoption (Giles-Corti, 2003 and Lopez et al., 2008). Further, another study by Giles-Corti found that the quality of the walking environment may be more important than the SES of the area of residence and, as a correlate, has the potential to influence participation in both walking and vigorous activity (Giles-Corti & Donovan, 2002). A related study from Owen et al found that, along with PAR accessibility, walking for recreation was repeatedly associated with pedestrian aesthetics (2004).

Pedestrian and Bicycle Facility Density and PA Adoption. Another example of environmental approaches to promote PA adoption includes the presence of pedestrian and bicycle facilities (i.e., pedestrian and bicycle facility density) (Brownson, Boehmer, & Luke, 2005; Saelens, Sallis, & Frank, 2003). Owen et al. (2004) also found that walking for recreation was repeatedly associated with convenience of facilities. Another study found that walking for transportation was related to the design of the neighborhood that would allow walking to nearby destinations (i.e. walkability) (Saelens et al., 2003). There were consistent associations of the overall walkability of the neighborhood design with walking and cycling for transportation. Walkability was defined by the combination of mixed land use, connected streets, and high residential density.

These relationships have also varied by gender. Wendel-Vos et al. examined walking behavior and found significant associations for the availability of sidewalks among men, but not in women. The authors note that generally, there were no differences between men and women regarding environmental determinants of PA (2007). A similar study found that gender differences were more difficult to interpret. Walking and moderate activity among women were positively associated with diversity of land use, ease of walking to a transit stop, access to local shopping, and emotional satisfaction with a neighborhood, but not with presence of sidewalks or satisfaction with neighborhood services (De Bourdeaudhuij, Sallis, & Saelens, 2003).

Even fewer studies have examined bicycle facility density as related to PA adoption (Goldsmith,1992 and Litman, 2000, Sallis, 1998). Because of these inconsistencies and an overall lack of empirical evidence, there is often insufficient data to make specific recommendations to policy makers, urban designers, or the construction industry to increase pedestrian and bicycle facility density in an effort to increase PA adoption.

Summary

This critical literature review was intended to present a detailed overview of the current knowledge related to the concordance between directly and indirectly measured built environment attributes, possible correlates of this concordance and PA adoption for AA and HL women. No research investigating built environment measurement concordance, its correlates and PA adoption among AA and HL women has been conducted to date; however, research related to the purpose of this proposal was presented. This information provided an understanding for the importance of conducting the proposed research as related to the following domains: 1) Ecologic models and the importance of the built environment, 2) direct built environment measurement, 3) indirect built environment measurement, 4) concordance of direct and indirect built environment measurement 5) correlates of concordance of direct and indirect built environment measurement 6) PA adoption among AA and HL women and 7) the relationship among direct and indirectly measured built environment attributes and PA.

PAR accessibility, **sidewalk maintenance, pedestrian and bicycle facility density** were addressed in all built environment measurement sections. In addition, the importance of studying AA and HL women was discussed. A brief overview of what has been learned for built environment measurement concordance as related to PA was also described.

All sections and literature were included in order for the reader to comprehend the background, significance and underlying mechanisms for the proposed methodology of this experiment. It is important to understand Ecologic models and both direct and indirect built environment measurement, specifics and examples of PAR, pedestrian and bicycle facilities direct and indirect measurement, as well as, typical terminology used to describe built environment measurement and attributes.

In this proposal, built environment assessments are used to explore direct and indirect built environment measurement concordance. Most built environment measurement concordance research reveals significant inconsistencies among direct and indirect measures (Foster & Giles-Corti, 2008; Gebel et al., 2009; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007). Further, little is known about possible correlates of this concordance. Last, minority women are at high risk for physical inactivity, obesity and other health maladies. These inconsistencies and significances were all discussed in this literature review and are in conjunction with the overall purpose of the proposed study. The next chapter (Chapter 3. Methodology) will explain the protocol and method of the proposed experiment as designed for its overall purpose: how directly measured built environment attributes relates to indirectly measured environmental perceptions and how attribute concordance relates to PA adoption among minority women.

CHAPTER 3

MANUSCRIPT: CONCORDANCE AND CORRELATES OF DIRECT AND INDIRECT BUILT ENVIRONMENT MEASUREMENT

INTRODUCTION

Ecological models suggest that individual, social and environmental factors are interrelated and associated with health behaviors (Sallis et al., 1998; Sallis and Owen, N., 1997; Spence, 2003). Ecological models incorporate interdependent intra- and extra-individual factors that may influence individual behaviors and attitudes at multiple levels (Sallis and Owen, N., 1997; Spence, 2003) and provide researchers with innovative opportunities for health interventions. Several studies have used ecological models as an underlying theoretical framework for investigating the associations between neighborhood features and perceptions, but results can vary based on the type of neighborhood assessment used (Ball et al., 2008 and Gebel et al., 2009). Greater familiarity with one's environment, or higher concordance, may provide greater incentive to be physically active in it, but few studies have systematically investigated this relationship.

Neighborhood built environments can be measured directly, using objective field assessments, or indirectly, using self-report questionnaires. Several direct environment assessment tools have emerged in recent years, enabling researchers to directly measure recreation facilities designed for physical activity (PA) (Brownson et al., 2004; Cerin, Saelens, Sallis, & Frank, 2006; Lee et al., 2005). The most commonly-used direct assessment tools have been extensively tested and peer reviewed (Clifton, 2007; Lee et al., 2005). Using direct measures, environmental attributes can be objectively defined and rated by field assessors based on independent definitions for each attribute's existence and/or a quality rating (Brownson et al., 2004; Cerin, Saelens, Sallis, & Frank, 2006; Lee et al., 2005). Earlier studies have directly measured built environment features like physical activity resources (PARs), and pedestrian and bicycle facilities (Heinrich et al., 2008; Lee et al., 2005; McAlexander et al., 2009).

Neighborhood built environments can also be measured indirectly using self-report questionnaires. Most evidence on the association between built environment attributes and PA is derived from indirect self-reported data or residents' perceptions of their environments (Gebel, Bauman, & Petticrew, 2007; Humpel, Owen, & Leslie, 2002). Indirect measures of the built environment include self-reported data on perceived environmental attributes. Data are collected by interviewers via telephone and in-person or by self-administered questionnaires by mail or email. These data can be aggregated to the neighborhood level, and neighborhood attributes can be identified geographically, by population and/or longitudinally (Brownson et al., 2009). Pikora et al. identified four important environmental domains to be measured: functional, safety, aesthetic and destination (Pikora, Giles-Corti, Bull, Jamrozik, & Donovan, 2003). This conceptual framework has been used to guide the creation and progression of self-reported questionnaires (Brownson et al., 2009). Although the format of most indirect built environment questionnaires varies, the underlying theoretical framework remains consistent among measures (Brownson et al, 2009).

Built environment measurement concordance is the correlation between direct and indirect assessments of the built environment. Concordance is measured by the strength and direction of the correlation between directly measured and indirectly measured variables of the built environment. For example, if a resident perceives that her neighborhood has high PAR accessibility, or that there are many free PARs to use, and directly measured data suggest that there is, in fact, high PAR accessibility for her neighborhood, a strong and positive concordance exists for PAR accessibility. If a resident perceives that her neighborhood has no PAR accessibility, or that there are no free PARs to use, and directly measured data suggest that about half of PARs are accessible, a weak and negative concordance exists for PAR accessibility. Few studies have systematically measured the concordance of directly and indirectly measured built environment attributes like PAR accessibility, path maintenance and pedestrian and bicycle facility density, or the number of pedestrian and bicycle facilities, and existing literature remains inconsistent. Ball et al. found that self-reports of walking/bicycling tracks located about 2 km from a participant's home were poorly correlated with objective data among Australian women (Ball et al., 2008). In contrast, Leslie and colleagues found that perceived neighborhood characteristics were significantly related to objectively assessed 'walkability' (2007).

Along with the problematic inconsistencies among existing built environment concordance literature, no study has examined concordance among the vulnerable population of minority women. Further, studies suggest that, in conjunction with other intra-individual factors like ethnicity and gender, the strength and direction of the concordance of directly and indirectly measured built environment attributes might also be affected by correlates such as BMI, body fat percentage and PA (Boehmer et al., 2007; Gebel et al., 2009; McGinn, Evenson, Herring, Huston et al., 2007). In other words, perceptions of the built environment can vary depending upon BMI, body fat percentage and/or PA levels. For example, consider an African American woman who lives in a lower SES neighborhood with few or no accessible PARs. Because she has recently walked in and around her neighborhood, she also correctly perceives this lack of few or no accessible PARs, thus demonstrating a strong concordance of directly and indirectly measured PAR accessibility. BMI, body fat percentage and PA have all been associated with direct *or* indirect built environment attributes (Handy, Boarnet, Ewing, & Killingsworth, 2002; McGinn, Evenson, Herring, Huston et al., 2007; Saelens, Sallis, & Frank, 2003), but few studies have systematically associated these correlates with the concordance of direct and indirect built environment attributes. No known study has examined objectively measured PA as a possible correlate of concordance.

Despite growth and development in this field of research, many questions remain about the relationship between the built environment and perceptions about the built environment. Many studies have associated built environment attributes or perceptions of built environment attributes to various types of PA, but few studies have investigated the relationship between built environment attributes and perceptions of built environment attributes. The purpose of this study was to measure the strength, direction and correlates, BMI, body fat percentage and PA, of the concordance of the following directly and indirectly measured built environment attributes: PAR accessibility, path maintenance and pedestrian and bicycle facility density among African American and Hispanic or Latina women. We hypothesized that women with lower BMIs, body fat percentages and who were more physically active, would demonstrate a stronger concordance of directly and indirectly measured built environment attributes.

METHOD

The Health is Power Project. This study involved secondary analyses based on data from the *Health is Power* project. The Health Is Power study was a five-year, longitudinal study funded by the National Cancer Institute of the National Institutes of Health (5R01CA109403-4) to increase PA and improve dietary habits in African American and Hispanic or Latina women in Houston and Austin, Texas.

Participants. Four hundred ten African American and Hispanic or Latina women completed physical assessments and interview administered questionnaires. See Table 1 for baseline participant demographic characteristics. Of those enrolled in Houston, 84.6% identified as African American and 15.4% identified as Hispanic or Latina; all participants in Austin identified as Hispanic or Latina. Preliminary criteria for participants were:

- African American and Hispanic or Latina Woman age 25-60 years.
- Not doing 30 minutes of moderate or vigorous PA in leisure time more than 3 times per week.
- Free from cardiovascular disease or other physical limitations that might be aggravated by participation in moderate intensity PA (must Physical Activity Readiness Questionnaire) (Thomas, Reading, & Shephard, 1992).
- Willingness to complete protocol and not planning to move in the following eighteen months.
- Able to read, speak and write in English or Spanish to participate in the intervention protocol.

- Residence in Harris or Travis County.
- Not pregnant or planning to become pregnant in the next 12 months.

(Lee et al., in press)

Study Design. In this study, environmental cross-sectional data was associated to measure the relationships between directly and indirectly measured built environment attribute data among African American and Hispanic or Latina women.

Individual Measures.

Indirectly Measured Built Environment Attributes. In order to indirectly measure each participant's neighborhood, the IPS *(International Physical Activity Prevalence Study*, 2002) environmental survey module was used (http://www-rohan.sdsu.edu/faculty/sallis/IPAQIPS.pdf) (Appendix A). The IPS questionnaire was used to assess the perceived environmental factors for PAR accessibility, path maintenance and pedestrian and bicycle facility density for each participant's neighborhood. The IPS environmental module has 17 sets of carefully chosen items that reflect current thinking in this field, and in which the reliability and validity of each item has been assessed (*International Physical Activity Prevalence Study*, 2002). For this study, the following variables from the IPS were analyzed and compared to objectively measured environmental data: PAR accessibility, path maintenance, pedestrian facility density and bicycle facility density.

PA Measures. To assess self-reported PA levels, the *IPAQ* (International Physical Activity Questionnaire) *Long Form* was used (Appendix A). The *IPAQ Long Form* indirectly assesses PA types like walking, moderate- and vigorous-intensity activities, for the past seven days. Median values and interquartile ranges are computed for walking, moderate intensity activities, vigorous-intensity activities and for a combined total PA score. The *total PA score* at T1 was used and all continuous scores were expressed in MET-minutes. The IPAQ sitting question is an additional indicator variable of time spent in sedentary activity but is not included as part of any total score of PA. Data on sitting is also reported as median values and interquartile ranges. The *IPAQ Long Form* is an instrument designed primarily for population surveillance of PA among adults age 15-69 years (International Physical Activity Questionnaire, 2005).

To objectively assess the amount and intensity of PA subjects do each day, accelerometers (MTI Actigraph) were used. Participants wore accelerometers on seven consecutive days at T1 to assess typical PA behavior for moderate and vigorous activity. Like the IPAQ, the *total* amount of moderate and vigorous accelerometer-measured PA (MVPA) was used for seven consecutive days.

Other Individual Measures. Body Composition was defined by both BMI and percent body fat. Participants removed shoes and heavy outer clothing, and trained research assistants measured height, using a portable stadiometer (Seca 225 Hite Mobile Measuring Device; North Bend, Washington), and weight, using a bioimpedence monitor with scales (The TBF-310 & the TBF-300; Tanita Corporation, Chicago of America, Arlington Heights, IL). Body fat was measured using the Tanita integrated bioelectrical impedance body fat monitor and scale (Tanita Body Fat Analyzer, TBF 105, Tanita Corporation of America, Inc., Arlington Heights, IL).

Sociodemographic measures of age, gender, marital status, employment status, years of education, and income range were measured using the Maternal and Infant Health Assessment (http://www.cdph.ca.gov/data/surveys/Pages/MaternalandInfantHealthAssessment (MIHA) survey.aspx were used. The MIHA survey is modeled on the CDC's Pregnancy Risk Assessment Monitoring System (PRAMS) and items have been used with samples representing a diverse range of ethnicities and socioeconomic status categories (Sarnoff and Hughes, 2005; California Department of Health Services, 2010)

Built Environment Measures

PAR Measure. PARs were assessed using the Physical Activity Resource Assessment Instrument (PARA) (Appendix A), that documents the accessibility, quantity, attributes, and quality of each available PAR in each neighborhood (Lee et al., 2005, Heinrich et al., 2008 and McAlexander, 2009). The PARA was used to assess the type of PAR, size and accessibility, or whether the resource was free to use. The instrument also assesses thirteen common PA related features like basketball courts, soccer fields, trails, tennis courts and exercise stations. Each feature is assigned quality ratings ranging from 1 "Poor" to 3 "Good," based on specific and comprehensive operational definitions. Earlier studies have demonstrated inter rater reliability of the instrument is good (*Kappas*>.77) (Heinrich et al., 2008, Lee et al., 2005), and the PARA completion time is shorter than other PAR assessment tools like BRAT-DO, EAPRS. In order to compare directly measured PAR accessibility to indirectly measured PAR accessibility, the PAR variable accessibility was extracted from all collected PAR data and the total number of accessible PARs was calculated for each participant's neighborhood.

Pedestrian and Bicycle Facility Measure. To directly assess pedestrian and bicycle facility attributes for each neighborhood, the Pedestrian Environment Data Scan (PEDS) (Clifton, 2007) instrument was used. The best pedestrian facility, as determined by Section B of the PEDS instrument, was chosen by the trained assessor(s). A pedestrian facility can include trails, sidewalks and/or pedestrian streets (Clifton, 2007), and several attributes can be directly measured based on the audit tool's objective definitions (Clifton, 2007). Path maintenance is assessed based on the amount of debris and/or the overall condition of the facility (Clifton, 2007). The PEDS tool defines the variable as follows:

Path Condition/Maintenance:

- Poor (many bumps, cracks, holes and weeds) A sidewalk will be considered "poor" if a stroller cannot be pushed along the sidewalk without many jarring motions and/or if it clearly needs to be replaced (patches would not be sufficient)
- Fair (some bumps, cracks, holes and weeds) A sidewalk will be considered "fair" if a stroller can easily be pushed along the sidewalk with few jarring motions to the passenger and/or it only needs patches or other minor repair.
- Good (very few bumps, cracks, holes and weeds) A sidewalk will be considered "good" if a stroller can easily be pushed along the sidewalk without jarring motions to the passenger and/or it needs no repair at this time.
- Under Repair A sidewalk will only be considered "under repair" if there is evidence of work being done to improve the sidewalk. Orange cones are not enough. If construction work is being done adjacent to the sidewalk, blocking it off as a result, it is considered "under repair."

Auditors choose one option based on the overall quality of the facility.

Pedestrian facility density is then calculated by counting the number of pedestrian facilities within each predefined neighborhood. Bicycle facilities are similar and are the defined as follows:

Bicycle Facilities

- No designated bikeway
- Bicycle route signs
- Striped bicycle lane designation
- Visible bicycle parking facilities: these facilities must be useable by the public, not for private use only
- Bicycle crossing warning

Bicycle facility density is defined as the number of bicycle facilities for each assessed segment within a neighborhood.

Individual Assessments. Participants completed an interviewer administered, self-report environmental perception questionnaire at T1 and self-reported PA measures at T1 and T2. Participants also completed a seven day accelerometer protocol at T1 and T2 and were compensated $20 for completing assessments at each time point.

Neighborhood Assessments and GIS Development. Participant street addresses were geocoded and plotted using the program ArcGIS by a trained Geographical Information Systems specialist. Each participant's neighborhood was restricted to an 800 meter or approximately 1/2 mile radius buffer. See Figure 4 below.

This predefined region allows for capture of the area to which most residents are likely to be exposed on a daily basis during foot, bicycle and automobile travels (Lee et al, 2003; Parmenter et al., 2008). Earlier studies have also used these boundaries to assess neighborhood features related to health behaviors and outcomes (Heinrich et al., 2008; Heinrich et al., 2007; Lee et al., 2005; McAlexander, Banda, McAlexander, & Lee, 2009).

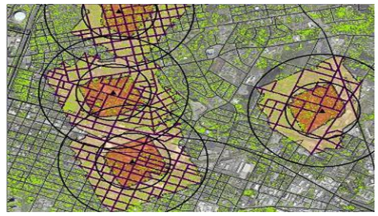

Figure 4: Sample map of 800m buffer for Health Is Power participants

Using GIS for neighborhood assessments has many advantages. GIS allows for environmental and individual data to be layered and simultaneously displayed. This type of view allows for multiple analyses while using only one map (Parmenter et al., 2008; Lee et al., 2003). Neighborhood attributes are associated with each mapped physical structure and are symbolically represented on the map display (Parmenter et al., 2008).

Environment assessments were completed during the intervention and maintenance period to capture neighborhoods at the same time in order to avoid simultaneity bias (Diez-Roux, 1998). Built environment features were mapped and integrated into each spatial display. All data collectors completed one full day of data collection training that included project description, instruction on variable definitions, field training and reliability testing (Parmenter et al., 2008).

PAR Assessments. PARs were identified via an internet search, vehicle windshield survey, and GIS data match for the area within an 800m radius around each participant's physical address. Physical address and map location were then determined for each PAR. Each PAR was counted for the neighborhood density calculation, or the number of PARs within 800m radius around each participant's physical address, and assessed.

Pedestrian and Bicycle Facility Assessments. To assess pedestrian and bicycle facilities, trained research assistants assessed all arterials and 25% of every residential segment, as sampled by ArcGIS, within every 400m buffer around each participant's home. Earlier data have suggested that street segment features do not significantly differ from a 400m radius buffer and an 800m radius buffer (Lee et al., 2010), allowing for more efficient, time and cost effective neighborhood street assessments.

Statistical Analyses. Appropriate descriptive analyses were performed to examine distributional characteristics for individual and environmental data. Individual measures were analyzed at T1 and bivariate analyses were conducted among all individual and neighborhood variables. All statistical analyses were conducted in SPSS Version 18.0 (SPSS 18.0 for Windows; SPSS Inc, Chicago, Ill).

To measure the concordance between objectively measured and self-reported built environment attributes, logistic regression was used to assess the ratios of the probability of choosing one indirectly measured indirect built environment category, disagree or agree, over the other category based on the directly measured built environment category, as determined by a likelihood ratio test for African American and Hispanic or Latina women. Because bivariate analyses suggested that BMI, body fat percentage and PA were not significantly associated with any directly or indirectly measured built environment attribute, these variables were not included in the models. To examine differences among African American and Hispanic or Latina, ethnicity was included as a factor in all models, and statistical significance was set at $p<.05$.

To measure the *strength* and *direction* of concordance between directly and indirectly measured built environment attributes, each logistic regression model's residual value was calculated as the indirectly measured built environment attribute category that each participant chose minus the predicted indirectly measured built environment attribute category that the model chose. Concordance was defined as a residual of 0, meaning that the predicted and selected category were equal. Negative residuals indicated that the participants' indirect measure of the environment was *worse* than that predicted by the directly measure of the environment, meaning that the participant reported that PAR accessibility in her neighborhood is low when in fact PAR accessibility is high. Positive residuals indicated that the participants' indirect measure of the environment was *better* than that predicted by the direct measure of the environment meaning that the participant reported that PAR accessibility in her neighborhood is high when in fact PAR accessibility is low.

RESULTS

Descriptive Characteristics

Participants' (*N*=409) average BMI was classified as obese (*M* BMI=34.5 kg/m^2, *SD*=7.9) and the mean body fat percentage was 42.8% (*SD*=7.1). Eighty-nine percent of participants had graduated from college or completed some college and almost 50% of participants reported an income 401% or greater above the Federal Poverty Level for a family of four (FPL, 2007). Demographic and physical characteristics by ethnicity are presented in Table 1 (Lee et al., in press).

Table 1. Baseline participant demographic characteristics by ethnicity

	African American (*N*=260)	**Hispanic or Latina** (*N*=149)
	N (%)	*N (%)*
Completed some college or more	242(97.9%)	102(73.4%)
401% or above the Federal Poverty Level	127(54.5%)	54(40.9%)
	M (SD)	*M (SD)*
Age (years)	44.8(9.4)	46.2(9.2)
BMI (kg/m^2)	35.3(8.6)	34.9(7.6)
Body fat (%)	43.3(6.9)	43.1(6.3)
Total PA (IPAQ)	2591.6(4034.1)	2694.6(3337.4)
Total PA (Accelerometer)	23.7(21.4)	10.8(10.1)

Directly Measured Built Environment Attributes

Most neighborhoods had one or more accessible PARs (96.1%, *N*=345) and 83% (*N*=309) of the neighborhoods had “good” sidewalk maintenance ratings. Seventy-nine neighborhoods had 14 or more pedestrian facilities (19.3%), yet nearly 75% had no bicycle facilities (*N*=284). Only one directly measured built environment attribute, bicycle facility density, varied by ethnicity ($F(1,378)=13.1$, $p<.001$). Directly measured built environment attributes by ethnicity are presented in Table 2 below.

Table 2. Direct built environment attributes by ethnicity

	African American (*N*=260)	**Hispanic or Latina** (*N*=149)
	N (%)	*N (%)*
PAR Accessibility		
Not Accessible	10(4.2%)	4(3.4%)
Accessible	230(95.8%)	115(96.6%)
Path condition		
Poor or Fair	39(15.9%)	21(16.9%)
Good	206(84.1%)	103(83.1%)
Pedestrian facility density		
0-5	57 (22.5%)	17 (13.4%)
6-8	51 (20.2%)	26 (20.5%)
9-10	45 (17.8%)	27(21.3%)
11-13	52(20.6%)	26(20.5%)
14+	48(19.0%)	31(24.4%)
Bicycle facility density		
0	203(80.2%)	81(63.8%
1	26(10.3%)	20(15.7%)
2+	24(9.5%)	26(20.5%)

Indirectly Measured Built environment Attributes

Most participants agreed that there were many free or low cost PARs in their neighborhood, paths on most of the streets and the paths were well maintained. Overall, African American women agreed that there were PARs and pedestrian facilities more so than Hispanic or Latina women. Fifty-five percent (*N*=71) of Hispanic or Latina women agreed that there were bicycle facilities in or around their neighborhood compared to 51% (*N*=122) of African American women. Indirectly measured built environment attributes by ethnicity are presented in Table 3.

Table 3. Indirectly measured built environment attributes by ethnicity

Indirect Built Environment Attribute	**IPS Question**	**African American** (*N*=260)	**Hispanic or Latina** (*N*=149)
		N (% agree*)*	*N (%* agree*)*
PAR Accessibility	My neighborhood has several free or low cost recreation facilities.	197(81.4%)	98(72.1%)
Path Condition	The sidewalks in my neighborhood are well maintained.	172(70.8%)	96(72.2%)
Pedestrian Facility Density	There are sidewalks on most streets of my neighborhood.	202(82.4%)	108(80.6%)
Bicycle Facility Density	There are facilities to bicycle in or around my neighborhood.	122(51.9%)	71(55.5%)

Bivariate Relationships Between Direct and Indirect Built Environment Attributes; Potential Correlates and Ethnicity

Bivariate analyses were conducted among direct, indirect built environment variables, BMI, body fat percentage, self reported physical activity, accelerometry, sociodemographic variables and ethnicity. Ethnicity, BMI, body fat and PA were not significantly associated with any built environment attribute. Results for direct and indirectly measured built environment attributes, potential correlates and ethnicity are presented in Table 4.

Table 4. Bivariate relationships between direct, indirect built environment attributes and correlates and ethnicity

		Direct Measure				**Indirect Measure**				**Correlates**			
		PAR access.	**Ped. facility density**	**Path main.**	**Bicycle facility density**	**PAR access.**	**Ped. facility density**	**Path main.**	**Bicycle facility density**	**BMI**	**BF**	**Acc. PA**	**IPAQ PA**
Indirect Measure	**PAR access.**	**.31**	---	---	---								
	Ped. facility density	---	2.38	---	---								
	Path main.	---	---	2.87	---								
	Bicycle facility density	---	---	---	3.90								
Correlates	**BMI**	*.00*	**-.05**	*.08*	**-.03**	*.11*	*.07*	*.04*	*.01*				
	BF	*.01*	**-.07**	*.12*	**-.02**	*.05*	*.04*	.05	.02	**.84***			
	Acc. PA	*.11*	**-.05**	*.21*	**-.11**	*.09*	*.07*	*.11*	*.11*	**-.05**	**-.04**		
	IPAQ PA	*.09*	-.05†	*.10*	.03†	*.07*	*.06*	*.07*	*.02*	.00†	-.01†	.06†	
	Eth.	3.34	*.05*	.85	*.14*	4.30	2.93	4.94	1.35	**.03**	*.04*	*.34*	*.06*

Note. Chi-square reported for corresponding direct and indirect built environment attribute comparisons; **Boldface** indicates Pearson's *r* correlation; *Italics* indicate Eta

†Spearman's Rho
*p<.01

Concordance of Direct and Indirect Built Environment Measurements

Because BMI, body fat percentage and PA were not significantly associated with any direct or indirect built environment attributes, BMI, body fat and PA were not included in the logistic regression models. Ethnicity and sociodemographic variables were included in the respective models. Logistic regression model results are presented in Table 5.

Table 5. Adjusted Odd Ratios from Logistic Regression of Indirectly Measured Built Environment Attributes

Outcome/ **Model Variables**	**β**	**Exp(B)**	**95% Confidence Interval**	**P –Value**
Indirectly measured PAR accessibility				
Directly measured PAR accessibility				
0	-.13	.88	.17-4.67	.88
1	.29	1.33	.56-3.20	.52
2	.14	1.15	.49-2.72	.75
3	.19	1.21	.48-3.03	.69
4	.32	1.38	.53-3.62	.52
5				
Ethnicity				
AA	-.28	.76	.44-1.31	.32
HL				
Intercept	-1.30			.00
Indirectly measured path maintenance				
Directly measured path maintenance				
Poor or Fair	.16	1.18	.63-2.20	.62
Good	0			
Ethnicity				
AA	.07	1.08	.65-1.78	.78
HL	0			
Intercept	-.99			.00
Indirectly measured pedestrian facility density				
Directly measured pedestrian facility density				
1	1.14	3.11	1.17-8.30	.02
2	.83	2.28	.85-6.15	.10
3	.21	1.23	.41-3.68	.71
4	-.11	.89	.28-2.85	.85
5	0			
Ethnicity				
AA	-.15	.86	.44-1.68	.66
HL				
Income				
0-200% FPL	-.20	.82	.32-2.09	.68
201-300% FPL	-.81	.45	.16-1.24	.12
301-400% FPL	.10	1.10	.48-2.51	.82
401%+ FPL	0			
Intercept	-1.86			.00
Indirectly measured bicycle facility density				
Directly measured bicycle facility density				
0	.20	1.22	.63-2.37	.55
1	.06	1.07	.45-2.51	.89
2+	.00			
Ethnicity				
AA	.18	1.20	.75-1.93	.45
HL	0			
Age	.00	1.00	.98-1.02	.97
Intercept	-.47			.45

Note. Last category of each predictor variable was used as reference category.

No regression model significantly predicted indirectly measured built environment attributes (PAR accessibility $X^2(6)=1.778$, $p=.939$; path maintenance: $X^2(2)=.326$, $p=.849$; pedestrian facility density $X^2(8)=14.714$, $p=.065$; bicycle facility density $X^2(4)=1.272$; $p=.866$). Residual (i.e. concordance) values were calculated for each attribute as follows: the actual category, chosen by each participant, minus the predicted category, based on the respective model. See Table 6 for residual values of each indirectly measured built environment attribute.

Table 6. Residual Values for Indirectly Measured Built Environment Attributes

Attribute		*N (%)*
PAR Accessibility		
	-2	14(3.9%)
	-1	78(21,7%)
	0	93(25.9%)
	1	65(18.1%)
	2	49(13.6%)
	3	60(16.7%)
Pedestrian facility density		
	-1	67(19.9%)
	0	68(20.2%)
	1	63(18.8%)
	2	67(19.9%)
	3	71(21.1%)
Path condition		
	-1	52(15.8%)
	0	277(84.2%)
Bicycle facility density		
	-1	275(74.3%)
	0	45(11.0%)
	1	50(13.5%)

Although a large percentage of participants misperceived their neighborhood or demonstrated non-concordance between their perceptions and the actual attributes, most of the non-concordance values were positive, suggesting that most women perceived that their neighborhood built environment attributes were better than they actually were. Almost 60% of residents had a positive non-concordance for pedestrian facility density and 48% demonstrated a positive non-concordance for PAR accessibility. Further, residual values were not significantly associated with any correlate (*p*s>.05). Although the models were not significant, several participants' perceptions demonstrated concordance. Eighty four percent (*N*=277) of participants' demonstrated concordance for path condition. Almost 26% (*N*=93) of participants had an accurate perception for PAR accessibility, but only 20.2% (*N*=68) of participants accurately perceived their neighborhood's pedestrian facility density. Most residents (74.3%, *N*=275) perceived a negative non concordance for bicycle facility density and only 12.2% (*N*=45) demonstrated concordance this attribute.

DISCUSSION

The purpose of this study was to measure the strength, direction and correlates of the concordance of the directly and indirectly measured built environment attributes among African American and Hispanic or Latina women. We hypothesized that women with lower BMIs, lower body fat percentages and who were more physically active, would demonstrate a stronger concordance of directly and indirectly measured built environment attributes. Overall, direct and indirect measures of attributes were not concordant, yet a large percentage of participants demonstrated a positive non concordance for some indirectly measured built environment attributes. BMI, body fat percentage or PA were not significantly associated with any direct or indirect measure of the built environment attributes.

Similar to earlier studies (Ball et al., 2008; McCormack et al., 2008), our direct and indirect measures of built environment attributes were not concordant. Unlike earlier studies (Boehmer et al., 2007; Gebel et al., 2009), our non concordance values did not differ by BMI, body fat or PA. For example, Ball and colleagues measured concordance in Australian women and found similar mismatch but found more non concordance among women with lower income, PA and self-efficacy for PA (2008).

Surprisingly, a large percentage of our participants demonstrated a positive non concordance for some built environment attributes, suggesting that these residents think that those built environment attributes are more supportive for PA than they actually are. These findings are unique and could have different causes, correlates and consequences (Ball et al., 2008) as earlier studies have shown more negative non concordances or underestimates of the built environment (Gebel et al., 2009). These positive non concordances and lack of significant correlates of concordance might be due to overestimations of neighborhood features and PA levels, specifically among women (Ball et al., 2008; Hoehner et al., 2005). Earlier studies suggest that indirectly measured neighborhood data are more closely linked to self-reported PA than directly measured neighborhood data (Ball et al., 2008; Hoehner et al., 2005).

There could be several explanations for our unique findings. Unlike Boehmer et al. and Gebel's studies, our sample consisted of only women, in particular, minority women. The relationships between PA and attribute concordance might differ for our population, as earlier findings suggest that the degree of built environment non concordance can vary among certain population subgroups (Ball et al., 2008). Also, our participants lived in suburban *and* urban areas. Most data describing the relationship(s) between concordance and BMI, body fat and/or PA are derived from urban or highly walkable areas (Boehmer et al., 2007; Gebel et al., 2009). The characteristics of our geographic areas differed greatly. This variance could have affected the relationships among built environment attribute concordance and its correlates.

There were more overestimations for PAR accessibility and pedestrian facility density than any other built environment attribute. Neighborhood residents could have overestimated the number of *inaccessible*, or pay-to-use, PARs because of their high SES level(s) since higher incomes could be allowing our participants use inaccessible PARs and overestimate the number of *accessible*, or free-to-use PARs, compared to low SES residents in low SES neighborhoods. Based on a similar study's findings, overestimations of pedestrian facility density could be due to our samples' education levels (Gebel et al., 2009). Gebel et al. found that residents' education attainment moderated the concordance of direct and indirect measures of street connectivity. Participants without a university education were 47% more likely to underestimate street connectivity (2009). Most of our participants had completed some college or more, possibly predicting an overestimation of pedestrian facility density. Further, data not shown suggests that most of our participants owned a car, allowing them to travel outside their local neighborhoods and possibly overestimate the number of pedestrian facilities in their *own* neighborhood.

This study has many strengths, and no similar studies of minority women exist. Unlike other studies examining built environment attributes (Ball et al., 2008; Boehmer et al., 2007; Gebel et al., 2009), we compared directly and indirectly measured built environment attributes between two *different* groups of ethnic minority women. Future studies comparing various ethnicities could also attempt to employ more equal sample sizes, in order to increase generalizability and comparison effectiveness. Although our study did not aim to compare the built environment attributes between two different cities, we did recruit participants from two different metropolitan areas. Researchers examining concordance could also compare directly and indirectly measured environmental data from various metropolitan areas. Further, this study investigated these relationships among the vulnerable population of minority women. Although African American and Hispanic or Latina women are disproportionately obese and physically inactive as compared to Caucasian women (Ogden et al., 2006; USDHHS, 1996), they continue to be understudied in ecological literature (Lee and Cubbin, 2009).

Other strengths of this study include the use of direct *and* indirect built environment measures. Many built environment studies have used direct *or* indirect measures (Brennan Ramirez et al., 2006; Heinrich et al., 2008; Lee et al., 2005; Lee, Cubbin & Winkleby, 2007; McAlexander et al., 2009), but few studies have measured the concordance between these two types of measurements (Ball et al., 2008; Gebel et al., 2009; Lackey and Kaczynski, 2009). This study also used a self reported PA questionnaire *and* accelerometry to measure PA, providing a comprehensive assessment of PA. We also used measured height and weight to calculate BMI, rather than self-report, helping to reduce bias and measurement error.

Our findings are limited to the population of African American and Hispanic or Latina women of higher SES and may not generalize to the general public (Ball et al., 2008; Gebel et al., 2009; Lackey and Kaczynski, 2009). Future studies could measure other groups to investigate the relationships between the built environment concordance, BMI, body fat and PA among different populations. Due to compliance and logistic reasons, the number of participants who wore accelerometers was significantly fewer than those who completed the IPAQ questionnaire. Future studies should attempt to recruit and assess an equal number of participants for both PA measures to provide a more comprehensive PA assessment.

In addition to other built environment attributes, residents' perceptions of other neighborhood factors, like safety and aesthetics, could be measured and compared to actual or audited neighborhood factors and associated to BMI, body fat and PA. Although our study did not aim to measure these factors, other individual attributes like exercise self-efficacy and health history could be included in future built environment attribute concordance studies. Including these additional variables might help to explain variance of attribute perceptions and if particular individual characteristics affect perceptions about neighborhood attributes. Although we did not seek to measure PA performed within the built environment, future studies could assess the types and amounts of PA completed within specific features of the built environment. Further, most participants were of higher SES, suggesting that residents could have self-selected these neighborhoods, having more means to do so, and have positive perceptions about their neighborhoods' PA options.

This study investigated built environment measurement concordance and potential correlates in two samples of minority women, yet there are potential benefits for individuals. Being less familiar with one's environment, or non concordant, may *not* be associated with weight status, PA and/or ethnicity for high SES ethnic minority women. These findings do not support similar earlier findings among other populations, suggesting that revisions of current Ecological models related to concordance, weight status and total PA might be needed for certain population subgroups. More similar studies among understudied populations, particularly vulnerable groups like ethnic minority women, are necessary to clarify whether built environment attribute concordance is important to health status and/or PA and whether current theoretical models should be amended. Also, it is possible that certain high SES minority women correctly perceive *other* built environment attributes not measured in our study. More study is needed to clarify specific built environment attributes that are important for health behaviors and whether accurate perceptions of these attributes are necessary. When measuring the built environment, researchers must consider the associations between directly and indirectly measured neighborhood data, weight status and PA, particularly among the highly susceptible population of minority women.

CHAPTER 4

MANUSCRIPT: CORREPONDENCE OF DIRECTLY AND INDIRECTLY MEAUSRED BUILT ENVIRONMENT ATTRIBUTES AND PHYSICAL ACTIVITY ADOPTION

INTRODUCTION

Ethnic minority women report lower levels of physical activity (PA) (Kruger, Yore, & Kohl, 2008) and are at higher risk for obesity and its comorbidities compared to whites (Ogden et al., 2006; USDHHS, 1996). Further, health attitudes and behaviors can differ by ethnicity (Gordon-Larsen, McMurray and Popkin, 1999; Harris, Walters and Waschull, 1991; Stern et al.,1982). PA adoption is an essential component for increasing PA levels and preventing and treating obesity. Studies that investigate built environment measurement factors related to the adoption of PA are extremely important as consistent evidence suggests that neighborhood characteristics and health behaviors are significantly related (Sallis, Bauman, & Pratt, 1998; Sallis and Owen, N., 1997; Lee, Cubbin & Winkleby, 2007; Heinrich et al., 2007; Lee et al., in press). Further, research suggests that factors influencing PA adoption are different for men and women (Biddle, 1985; Caspersen, 1990), and there may be different factors influencing behavior adoption versus maintenance (Dunton and Vaughan, 2008; Marshall and Biddle, 2001).

Since the adoption of PA is key to the prevention of weight gain and numerous health maladies, studies that investigate built environment measurement factors related to the adoption of PA are extremely important. Ecological and social-ecological models of human behavior have evolved over decades in the fields of sociology, psychology and public health (Green, Richard, & Potvin, 1996; Sallis et al., 1998; Spence and Lee, 2003; Lee and Cubbin, 2009) and their significance to PA is now widely recognized (Breslow, 1996; McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis et al., 1998; Lee and Cubbin, 2009). For example, built environmental changes can benefit all people in a surrounding neighborhood rather than only focusing on changing the behavior of one person at a time (Lee & Cubbin, 2009). These changes can include building and improving physical activity resources (PARs), sidewalks and bicycle facilities and can be more permanent than interventions focusing on individual-level change. Further, specific built environment attributes can provide opportunities, support, and cues to help people adopt PA and complement individual level-programs. Empirical evidence consistently supports these associations (Sallis and Owen, 1997, Sallis, Bauman et al., 1998, Heinrich et al., 2007; Lee, Cubbin & Winkleby, 2007; Lee et al., in press), but less is known about how built environment attributes affect PA adoption, especially among the vulnerable population of minority women (Lee and Cubbin, 2009).

In particular, the concordance of directly measured built environment attributes and indirectly measured built environment attributes has been significantly associated with PA (Gebel et al., 2009; Humpel, 2004). Concordance is measured by the strength and direction of the correlation between directly measured and indirectly measured variables of the built environment (Gebel, Bauman, & Owen, 2009; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007). Direct built environment measures may provide objective data, unbiased by resident perceptions, as well as specific evidence for policy change impacting urban planning and transportation, both significant correlates of adopting PA. Indirect built environment measures include self-reported data on perceived environmental attributes and can provide insight on individual attitudes about the built environment. Both direct and indirect measures of the built environment have been associated with PA (Bengoechea, 2005; Evenson et al., 2007; Foster & Giles-Corti, 2008; Heinrich et al., 2007; Lee et al., in press; Troped et al., 2001; Velasquez, Holahan, & You, 2009), but the concordance of direct and indirect measures is inconsistent (Foster & Giles-Corti, 2008; Gebel, Bauman, & Owen, 2009; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007).

Even fewer studies have examined the association between concordance and PA, and no studies have examined concordance and PA adoption. For example, individuals who are less physically active may be more likely to misperceive their built environment as compared to those who more physically active (Gebel, Bauman, & Owen, 2009), suggesting that the concordance or non-concordance of direct and indirect built environmental measurement may be dynamic and related to PA adoption. See Figure 1 (Chapter 3).

Figure 1 suggests that, in conjunction with other intra-individual factors like ethnicity and gender, the strength and direction of the concordance of directly and indirectly measured built environment attributes might be affected by correlates such as BMI, PA and body fat and may be associated with PA adoption.

No studies have associated the concordance of directly and indirectly measured built environment attributes to PA adoption among any population. The purpose of this study was to measure the associations between built environment attribute concordance and PA adoption among African American and Hispanic or Latina women. We hypothesized that women who demonstrated a stronger concordance of directly and indirectly measured built environment attributes would exhibit greater PA adoption.

METHOD

The Health is Power Project. This study involved secondary analyses based on data from the *Health is Power* project. The goals of the Health Is Power project were (1) to determine whether a 24 week, social cohesion intervention was more effective for increasing PA in comparison to a fruit and vegetable comparison condition in African American and Hispanic or Latina women, (2) to determine whether PA is more effectively maintained by social cohesion participants who reside in high supportive PA environments in comparison to social cohesion participants who reside in low supportive PA environments.

Participants. Four hundred ten African American and Hispanic or Latina women (311 in Houston and 99 in Austin) were enrolled in the study and assessed. Of those enrolled in Houston, 84.6% identified as African American and 15.4% identified as Hispanic or Latina; all participants in Austin identified as Hispanic or Latina.

The sample characteristics that will be used for this study is that of the Health is Power Project. Preliminary criteria for Health Is Power participants were:

- African American and Hispanic or Latina Woman age 25-60 years.
- Not doing 30 minutes of moderate or vigorous PA in leisure time more than 3 times per week.
- Free from cardiovascular disease or other physical limitations that might be aggravated by participation in moderate intensity PA (verified by Physical Activity Readiness Questionnaire) (Thomas, Reading, & Shephard, 1992).

- Willingness to complete protocol and not planning to move in the following eighteen months.
- Able to read, speak and write in English or Spanish to participate in the intervention protocol.
- Residence in Harris or Travis County.
- Not pregnant or planning to become pregnant in the next 12 months.

Study Design. Environmental cross-sectional data were associated to measure the relationships between directly and indirectly measured built environment attribute data among African American and Hispanic or Latina women. Although participants were randomized into two different treatment groups, PA levels differences did not significantly differ by treatment group (Lee et al., 2010), so both treatment groups were collapsed into two separate samples based only on ethnicity. To examine longitudinal correlates of PA adoption among the two samples, PA level differences, calculated from T1 to T2, were associated to the degree of concordance for directly and indirectly measured environmental data collected at T1.

Individual Measures.

Sociodemographic measures of age, gender, marital status, employment status, years of education, and income range were measured using the Maternal and Infant Health Assessment (http://www.cdph.ca.gov/data/surveys/Pages/MaternalandInfantHealthAssessment (MIHA) survey.aspx were used. The MIHA survey is modeled on the CDC's Pregnancy Risk Assessment Monitoring System (PRAMS) and items have been used with samples representing a diverse range of ethnicities and socioeconomic status categories (Sarnoff and Hughes, 2005; California Department of Health Services, 2010).

Indirectly Measured Built Environment Attributes. In order to indirectly measure each participant's neighborhood, the IPS *(International Physical Activity Prevalence Study*, 2002) environmental survey module was used (http://www-rohan.sdsu.edu/faculty/sallis/IPAQIPS.pdf) (Appendix A). The IPS questionnaire was used to assess the perceived environmental factors for PAR accessibility, path maintenance and pedestrian and bicycle facility density for each participant's neighborhood. The IPS environmental module has 17 sets of carefully chosen items that reflect current thinking in this field, and in which the reliability and validity of each item has been assessed (*International Physical Activity Prevalence Study*, 2002). For this study, the following variables from the IPS were analyzed and compared to objectively measured environmental data: PAR accessibility, path maintenance, pedestrian facility density and bicycle facility density.

PA Measures. To assess self-reported PA levels, the *IPAQ* (International Physical Activity Questionnaire) *Long Form* was used (Appendix A). The *IPAQ Long Form* indirectly assesses PA types (walking, moderate- and vigorous-intensity activities), for the past seven days. Median values and interquartile ranges are computed for walking, moderate intensity activities, vigorous-intensity activities and for a combined total PA score. The *total PA score* at T1 was used along with the *total PA score* at T2 to measure PA differences from T1 to T2 or PA adoption. All continuous scores were expressed in MET-minutes. The IPAQ sitting question is an additional indicator variable of time spent in sedentary activity but is not included as part of any total score of PA. Data on sitting is also reported as median values and interquartile ranges. The *IPAQ Long Form* is an instrument designed primarily for population surveillance of PA among adults age 15-69 years (International Physical Activity Questionnaire, 2005).

To objectively assess the amount and intensity of PA subjects do each day, accelerometers (MTI Actigraph) were used for seven consecutive days. Participants wore accelerometers on seven consecutive days at T1 and T2 to assess typical PA behavior for moderate and vigorous activity. Like the IPAQ, the *total* amount of accelerometer-measured PA was used (the sum of PA for seven consecutive days) along with the *total* accelerometer-measured PA at T2 to measure PA differences or PA adoption.

Body composition was defined by both BMI and percent body fat. Participants removed shoes and heavy outer clothing, and trained research assistants measured height, using a portable stadiometer (Seca 225 Hite Mobile Measuring Device; North Bend, Washington), and weight, using a bioimpedence monitor with scales (The TBF-310 & the TBF-300; Tanita Corporation, Chicago of America, Arlington Heights, IL). Body fat was measured using the Tanita integrated bioelectrical impedance body fat monitor and scale (Tanita Body Fat Analyzer, TBF 105, Tanita Corporation of America, Inc., Arlington Heights, IL).

Built Environment Measures

PAR Measure. PARs were assessed using the Physical Activity Resource Assessment Instrument (PARA) (Appendix A), that documents the accessibility, quantity, attributes, and quality of each available PAR in each neighborhood (i.e., 800m buffer) (Lee et al., 2005, Heinrich et al., 2008 and McAlexander, 2009). The PARA was used to assess the type of PAR, size and accessibility, whether the resource was free to use or not. The instrument also assesses thirteen common PA related features (basketball courts, soccer fields, trails, tennis courts, exercise stations, etc.), which are assigned quality ratings ranging from 1 “Poor” to 3 “Good,” based on specific and comprehensive operational definitions. Earlier studies have demonstrated inter rater reliability of the instrument is good (*Kappas*>.77) (Heinrich et al., 2008, Lee et al., 2005). and the PARA completion time (~10 minutes) is shorter than other PAR assessment tools (e.g., BRAT-DO, EAPRS). In order to compare directly measured PAR accessibility to indirectly measured PAR accessibility, the PAR variable accessibility was extracted from all collected PAR data and the total number of accessible PARs was calculated for each participant’s neighborhood.

Pedestrian and Bicycle Facility Measure. To directly assess pedestrian and bicycle facility attributes for each neighborhood, the Pedestrian Environment Data Scan (PEDS) (Clifton, 2007) instrument was used (McMillan, in press). The best pedestrian facility, as determined by Section B of the PEDS instrument, was chosen by the trained assessor(s). A pedestrian facility includes trails, sidewalks and/or pedestrian streets (Clifton, 2007). Several attributes can be directly measured based on the audit tool’s objective definitions (Clifton, 2007). Path maintenance is assessed based on the amount of debris and/or the overall condition of the facility (Clifton, 2007). The PEDS tool defines the variable as follows:

Path Condition/Maintenance:

- Poor (many bumps, cracks, holes and weeds) A sidewalk will be considered “poor” if a stroller cannot be pushed along the sidewalk without many jarring motions and/or if it clearly needs to be replaced (patches would not be sufficient)

- Fair (some bumps, cracks, holes and weeds) A sidewalk will be considered “fair” if a stroller can easily be pushed along the sidewalk with few jarring motions to the passenger and/or it only needs patches or other minor repair.
- Good (very few bumps, cracks, holes and weeds) A sidewalk will be considered “good” if a stroller can easily be pushed along the sidewalk without jarring motions to the passenger and/or it needs no repair at this time.
- Under Repair A sidewalk will only be considered “under repair” if there is evidence of work being done to improve the sidewalk. Orange cones are not enough. If construction work is being done adjacent to the sidewalk, blocking it off as a result, it is considered “under repair.”

Auditors choose one option based on the overall quality of the facility.

Pedestrian facility density is then calculated by counting the number of pedestrian facilities within each predefined neighborhood (i.e. 800m radius circle). Bicycle facilities are similar and are the defined as follows:

Bicycle Facilities

- No designated bikeway
- Bicycle route signs
- Striped bicycle lane designation
- Visible bicycle parking facilities: these facilities must be useable by the public, not for private use only
- Bicycle crossing warning

Bicycle facility density is defined as the number of bicycle facilities for each assessed segment within a neighborhood (i.e. 800m buffer).

Individual Assessments. Participants completed an interviewer administered, self-report environmental perception questionnaire at T1 and self-reported PA measures at T1 and T2. Participants also completed a seven day accelerometer protocol at T1 and T2 and were compensated $20 for completing assessments at each time point.

Neighborhood Assessments and GIS Development. Participant street addresses were geocoded and plotted using the program ArcGIS by a trained Geographical Information Systems specialist. Each participant's neighborhood was restricted to an 800 meter or approximately 1/2 mile radius buffer. This predefined region allows for capture of the area to which most residents are likely to be exposed on a daily basis during foot, bicycle and automobile travels (Lee et al, 2003; McMillan et al., in press; Parmenter et al., 2008). Earlier studies have also used these boundaries to assess neighborhood features related to health behaviors and outcomes (Heinrich et al., 2008; Heinrich et al., 2007; Lee et al., 2005; McAlexander, Banda, McAlexander, & Lee, 2009).

Using GIS for neighborhood assessments has many advantages. GIS allows for environmental and individual data to be layered and simultaneously displayed. This type of view allows for multiple analyses while using only one map (Lee et al., 2003). Also, neighborhood attributes are associated with each mapped physical structure (e.g., green spaces, schools, some PARs) and are symbolically represented (e.g., lines, circles, flags) on the map display (Parmenter et al., 2008).

Environment assessments were completed during the intervention and maintenance period to capture neighborhoods at the same time in order to avoid simultaneity bias (Diez-Roux, 1998). All built environment features were mapped and integrated into each spatial display. All data collectors completed one full day of data collection training that included project description, instruction on variable definitions, field training and reliability testing (Parmenter et al., 2008).

PAR Assessments. PARs were identified via an internet search, vehicle windshield survey, and GIS data match for the area within an 800m radius around each participant's physical address. Physical address and map location were then determined for each PAR. Each PAR was counted for the neighborhood density calculation (number of PARs within 800m radius around each participant's physical address) and assessed.

Pedestrian and Bicycle Facility Assessments. Trained research assistants assessed all arterials and 25% of every residential segment, as sampled by ArcGIS, within every 400m buffer around each participant's home. Earlier data have suggested that street segment features do not significantly differ from a 400m radius buffer and an 800m radius buffer (McMillan et al., in press), allowing for more efficient, time and cost effective neighborhood street assessments.

Statistical Analyses. Appropriate descriptive analyses were performed to examine distributional characteristics for individual and environmental data. BMI, body fat percentage, PA and accelerometry were analyzed at T1 and T2 and bivariate analyses were conducted among all individual and neighborhood variables. All statistical analyses were conducted in SPSS Version 18.0 (SPSS 18.0 for Windows; SPSS Inc, Chicago, Ill).

To measure the concordance between objectively measured and self-reported built environment attributes, logistic regression was used to assess the ratios of the probability of choosing one indirectly measured indirect built environment category (i.e., disagree, agree) over another category based on the directly measured built environment category (e.g., poor/fair, good) as determined by a likelihood ratio test. Because bivariate analyses suggested that BMI, body fat percentage and PA were not significantly associated with any built environment attribute (directly or indirectly measured), these variables were not included in the models. To examine differences among AA and HL, ethnicity was included as a factor in all models, and statistical significance was set at $p<.05$.

To measure the *strength* and *direction* of concordance between directly and indirectly measured built environment attributes among AA and HL, each multinomial model's residual value was calculated as the indirectly measured built environment attribute category (disagree, agree) that each participant chose minus the predicted indirectly measured built environment attribute category that the model chose, based on each directly measured built environment attribute. Concordance was defined as a residual of 0 meaning that the predicted and selected category was equal. Negative residuals indicated that the participants' indirect measure of the environment was *worse* than that predicted by the direct measure environment, meaning that the participant reported that PAR accessibility in her neighborhood is low when in fact PAR accessibility is high. Positive residuals indicated that the participants' indirect measure of the environment was *better* than that predicted by the direct measure of the environment, meaning that the participant reported that PAR accessibility in her neighborhood is high when in fact PAR accessibility is low.

General linear models (GLM) with repeated measures were conducted to determine if the concordance value of each model was associated with PA adoption, or total PA change from T1 to T2, for both the IPAQ and accelerometry. The F-ratio test significance was set at $p<.05$.

RESULTS

Descriptive Characteristics. Participants' (*N*=409) average BMI at T1 and T2 was classified as obese (*M* BMI=34.5 kg/m^2, *SD*=7.9 and *M* BMI=34.2 kg/m^2, *SD*=8.1) (Lee et al., in press). Demographic and physical characteristics at T1 and T2 are presented in Table 7.

Table 7. T1 and T2 participant demographic characteristics by ethnicity

	African American T1 (*N*=260) T2(*N*=142)	**Hispanic or Latina** T1 (*N*=149) T2 (*N*=56)
	N (%)	*N (%)*
Completed some college or more	242(97.9%)	102(73.4%)
401% or above the Federal Poverty Level	127(54.5%)	54(40.9%)
	M (SD)	*M (SD)*
Age (years)	44.8(9.4)	46.2(9.2)
T1 BMI (kg/m^2)	35.3(8.6)	34.9(7.6)
T1 Body fat (%)	43.3(6.9)	43.1(6.3)
T1 Total PA (IPAQ)	2591.6(4034.1)	2694.6(3337.4)
T1 Total PA (Accelerometer)	23.7(21.4)	10.8(10.1)
T2 BMI (kg/m^2)	34.6(8.2)	33.5(7.7)
T2 Body fat (%)	42.6(7.2)	41.6(7.6)
T2 Total PA (IPAQ)	3326.5(3169.5)	2840.5(2067.0)
T2 Total PA (Accelerometer)	24.4(19.9)	11.72(9.1)

Built Environment Attributes and Concordance Residual Values.

All built environment attributes, multinomial regression model results and concordance values are reported in Chapter 3. Directly measured built environment attributes by ethnicity and indirectly measured built environment attributes by ethnicity are presented in Tables 3 and 4. Bivariate analyses were conducted among direct, indirect built environment variables, BMI, body fat percentage, self-reported PA, sociodemographic variables and ethnicity. Ethnicity, BMI, body fat and PA were not significantly associated with any directly or indirectly measured built environment attribute. Results for bivariate relationships between direct and indirectly measured built environment attributes, potential correlates and ethnicity are presented in Table 5.

Because BMI, body fat percentage and PA were not significantly associated with any direct or indirect measure of built environment attributes, BMI, body fat and PA were not included in the logistic regression models measuring concordance. Ethnicity and significant sociodemographic variables were included. Logisitic regression model results are presented in Table 6. No model significantly predicted indirectly measured built environment attributes. Residual values were calculated for each indirectly measured built environment attributes and are presented in Table 6.

Built Environment Attribute Concordance and PA Adoption

GLM repeated measures analyses suggested no significant relationships between any built environment attribute concordance value and PA adoption for total self-reported or objectively measured PA. Self-reported PA significantly increased over time ($F(1,184)=7.82$, $p=.006$) but this increase did not vary by ethnicity or any built environment attribute concordance value. Objectively measured PA did not significantly increase over time. Results for the GLM repeated measures for self-reported and objectively measured PA adoption are presented in Tables 8 and 9.

Table 8. GLM Repeated Measures results for self-reported PA adoption

Built Environment Concordance Attribute Used	**Effect**	***df***	***F***	***p*-value**
PAR Access				
	Time	1	2.69	.10
	Time*Ethnicity	1	.00	.99
	Time*PAR Access Concordance	1	.12	.73
	Time*Ethnicity*PAR Access Concordance	1	.71	.40
	Error	162		
Path Maintenance				
	Time	1	2.39	.12
	Time*Ethnicity	1	.01	.91
	Time*Path Maintenance Concordance	1	.84	.36
	Time*Ethnicity*Path Maintenance Concordance	1	.01	.91
	Error	153		
Pedestrian Facility Density				
	Time	1	2.17	.14
	Time*Ethnicity	1	.21	.65
	Time*Pedestrian Facility Density Concordance	1	.16	.69
	Time*Ethnicity*Pedestrian Facility Density Concordance	1	.47	.49
	Error	158		
Bicycle Facility Density				
	Time	1	7.22	.01
	Time*Ethnicity	1	.61	.44
	Time*Bicycle Facility Density Concordance	1	.79	.38
	Time*Ethnicity*Bicycle Facility Density Concordance	1	.44	.51
	Error	173		

Table 9. GLM repeated measures results for objectively-measured PA adoption

Built Environment Concordance Attribute Used	**Effect**	***df***	***F***	***p*-value**
PAR Access				
	Time	1	1.85	.18
	Time*Ethnicity	1	.61	.44
	Time*PAR Access Concordance	1	.20	.66
	Time*Ethnicity*PAR Access Concordance	1	1.83	.19
	Error	36		
Path Maintenance				
	Time	1	.80	.38
	Time*Ethnicity	1	.29	.59
	Time*Path Maintenance Concordance	1	.35	.56
	Time*Ethnicity*Path Maintenance Concordance	1	.22	.64
	Error	35		
Pedestrian Facility Density				
	Time	1	1.63	.21
	Time*Ethnicity	1	.60	.45
	Time*Pedestrian Facility Density Concordance	1	.86	
	Time*Ethnicity*Pedestrian Facility Density Concordance	1	.94	.36
	Error	36		
Bicycle Facility Density				
	Time	1	.118	.73
	Time*Ethnicity	1	.07	.80
	Time*Bicycle Facility Density Concordance	1	.23	.63
	Time*Ethnicity*Bicycle Facility Density Concordance	1	.09	.77
	Error	40		

DISCUSSION

The purpose of this study was to measure the associations between built environment attribute concordance and PA adoption in African American and Hispanic or Latina women. We hypothesized that women who demonstrated a stronger concordance of directly and indirectly measured built environment attributes would exhibit greater PA adoption. Overall, direct and indirect measures of attributes were not concordant, yet a large percentage of participants demonstrated a positive non concordance for some indirectly measured built environment attributes. Objectively measured PA did not significantly increase in either sample, but self-reported PA did significantly increase from T1 to T2. Self reported PA adoption did not vary by ethnicity or any concordance measure.

Similar to earlier studies (Ball et al., 2008; McCormack et al., 2008) our direct and indirect measures of built environment attributes were not concordant. Unlike these earlier studies, our non concordance values did not differ by ethnicity, BMI, body fat or PA. Further, there were no significant relationships between any built environment attribute concordance value, ethnicity and PA adoption. Although no study has measured the association between concordance and PA adoption, PA had been a significant correlate of built environment attribute concordance (Boehmer et al., 2007; Gebel et al., 2009). For example, Ball and colleagues measured concordance in Australian women and found similar mismatch but found more non concordance among women with lower income, PA and self-efficacy for PA (2008).

Although unexpected, a large percentage of participants demonstrated a positive non concordance for some indirectly measured built environment attributes, suggesting that these residents think that certain built environment attributes are more supportive for PA than they actually are. These findings are unique and could have different causes, correlates and consequences (Ball et al., 2008) as earlier data have shown more negative non concordances or underestimates of built environment attributes (Gebel et al., 2009). Women who overestimate the PA opportunities in their neighborhood might also overestimate their PA levels as earlier studies suggest that indirectly measured neighborhood data are more closely linked to self-reported PA than directly measured neighborhood data (Ball et al., 2008; Hoehner et al., 2005).

There could be several explanations for our unique findings. Unlike earlier, similar studies, our sample consisted of only minority women. The relationships between PA and attribute concordance might differ for our population, as earlier findings suggest that the degree of built environment non concordance can vary among certain population subgroups (Ball et al., 2008). Also, our participants lived in suburban *and* urban areas. Most data describing the relationship(s) between PA and concordance are derived from urban or highly walkable areas (Boehmer et al., 2007; Gebel et al., 2009). Although our residents were primarily of high SES, their directly measured neighborhood attributes and geographic areas varied greatly. Further, data not shown suggested that most women and/or family owned at least one car. Some high SES residents could be living in impoverished and less supportive neighborhoods and driving to other, more affluent and supportive neighborhoods with better and/or more PARs. Our samples' high individual SES levels might be buffering the effect(s) neighborhood SES has on PA adoption. All of the above factors could have affected the relationships among built environment attribute concordance, its correlates and PA adoption.

This study has many strengths and contributes to an evidence base where no similar data among minority women exist. PA adoption is an essential component to a healthy lifestyle (Centers for Disease Control and Prevention, 2009; USDHHS, 1996), yet no known study has measured the association(s) of PA adoption with built environment concordance values. Further, this study investigated these relationships among the vulnerable population of minority women. Although African American and Hispanic or Latina women continue to be disproportionately physically inactive compared to white women (Ogden et al., 2006; USDHHS, 1996), they continue to be understudied in ecological literature (Lee and Cubbin, 2009).

Other strengths of this study include the use of direct *and* indirect built environment measures. Many built environment studies have used direct *or* indirect measures (Brennan Ramirez et al., 2006; Heinrich et al., 2008; Lee et al., 2005; Lee, Cubbin & Winkleby, 2007; McAlexander et al., 2009), but few studies have measured the concordance between these two types of measurements (Ball et al., 2008; Gebel et al., 2009; Lackey and Kaczynski, 2009). This study also used a self reported PA questionnaire *and* accelerometry to measure PA adoption, providing a comprehensive assessment of PA. Although similar studies have been cross-sectional in nature (Ball et al., 2008; Gebel et al., 2009; Lackey and Kaczynski, 2009), our study measured PA longitudinally, allowing us to compare built environment attribute concordance to an essential health behavior, PA adoption. We also used measured BMI, body fat percentage, rather than self-report, helping to reduce bias and measurement error.

Our study is not without limitations. Due to adherence and logistic reasons, the number of participants who wore accelerometers was significantly fewer than those who completed the self-reported PA questionnaire at both time points. Future studies should attempt to recruit and assess an equal number of participants for both PA measures to provide a more comprehensive PA assessment. Also, we did not include some individual characteristics in our analyses. Additional individual variables (e.g., exercise self-efficacy, perceived stress levels, health history) could be measured to explain non concordances, in addition to other neighborhood perceptions. For example, McCormack and colleagues found that residents' cognitions were mediators in the relationship between the built environment and PA (2009). Including other individual variables might help to explain the variance of attribute perception(s) and PA adoption among these populations. Although our study did not aim to measure PA performed within the built environment, future studies could also measure the types and amounts of PA completed within specific features of the built environment.

Our study did not intend to compare built environment attributes and PA levels between two different cities, but we did recruit participants from two metropolitan areas. Future studies could compare directly and indirectly measured environmental data from various places and measure the effect(s) concordance has on PA adoption in various geographic areas. In addition to other built environment attributes, residents' perceptions of other neighborhood factors (e.g., safety, incivilities) (e.g., Boslaugh et al., 2004) could be measured and compared to actual or audited neighborhood factors and associated to PA.

This study investigated built environment measurement concordance and PA adoption in two samples of minority women, yet there are potential benefits for individuals. Being less familiar with one's environment, or not concordant, may *not* be associated with PA adoption. Also, it is possible that certain high SES minority women who misperceive *other* built environment attributes, not measured in our study, might be more likely to adopt PA, particularly among those who live in supportive neighborhoods. These findings suggest that direct, indirect and the concordance of direct and indirect built environment attributes among minority women is not associated with PA adoption.

Future PA interventions and supportive communities could promote built environment attributes (e.g., park amenities, clean baseball fields, long walking trails) in an attempt to increase PA adoption. Although our participants were primarily of high SES, it is possible that these residents are unsure of what types of built environment features promote PA or where these features are located. Urban policies could attempt to increase facility and street signage in an effort to promote PA, particularly among neighborhoods with more various population subgroups or ethnically diverse. More study is needed to clarify specific built environment attributes that are important for PA adoption and whether accurate perceptions of these attributes are necessary. Although the influence of the built environment on individual health behaviors has been well established, more study of the processes and interactions of specific built environment attributes and intra-individual factors like gender and ethnicity is needed. These linkages are not well understood, and the applicability of Ecological frameworks could be limited if the relationships between built environment attributes and health behaviors vary for certain personal characteristics. In an effort to promote PA, educators, community leaders and investigators must consider the multifaceted and intricate associations between built environment attribute concordance and PA adoption, particularly among the highly vulnerable population of minority women.

CHAPTER 5

SUMMARY, FUTURE DIRECTIONS, AND LIMITATIONS

Summary

Despite growth and development in ecological research, many questions remain about the relationships between the built environment and perceptions about the built environment, and whether accurate perceptions are important for PA adoption. This dissertation investigated built environment attribute concordance, its potential correlates and its association to PA adoption among minority women. A better understanding of built environment attribute concordance, its correlates and whether concordance is related to PA adoption can: 1) address inconsistencies and answer questions about the relationships between the built environment and perceptions about the built environment, 2) determine whether accurate perceptions are important for PA adoption and 3) provide meaningful data for understudied populations for whom no similar data exist. Two research questions and one hypothesis was tested among AA and HL women in this dissertation. The first research question investigated the strength and direction of the concordance between directly and indirectly measured built environment attributes. Community-dwelling AA and HL women self-reported their environmental perceptions at baseline. Results suggested that direct and indirect measures of attributes were not concordant, yet a large percentage of participants demonstrated a positive non concordance for some indirectly measured built environment attributes. The second research question tested BMI, body fat percentage and PA as potential correlates of the concordance. None were significant correlates among AA or HL women. Last, our general hypotheses, whether a higher concordance between directly and indirectly measured built environment attributes would be associated with greater PA Adoption, was tested. According to self-reported data, our participants did adopt PA, but PA adoption did not vary by ethnicity or concordance.

Being less familiar with certain built environment attributes may *not* be associated with PA adoption among minority women because concordance may have different correlates, consequences and causes among different population subgroups. Future PA interventions and supportive communities could promote built environment attributes (e.g., park amenities, clean baseball fields, long walking trails) in an attempt to increase PA adoption. In addition, urban policies could increase facility and street signage in an effort to promote PA, particularly among neighborhoods with various population subgroups or ethnically diverse neighborhoods. Additional individual variables should also be measured to explain non concordances, in addition to other neighborhood perceptions. We also suggest more study to determine whether *other* directly and indirectly measured built environment attributes concord, whether certain factors affect their concordance and whether accurate perceptions of built environment attributes are important for PA adoption, particularly among ethnic minority women.

Future Directions

This dissertation provides unique and meaningful data, but more study is needed. Our non concordance values could have different causes and effects, particularly when associated with PA adoption among minority women. Future studies could attempt to employ more equal sample sizes among different ethnicities, in order to increase generalizability and comparison. Further, the relationships among built environment concordance, BMI, body fat and PA could be investigated for other populations like low

SES groups or other ethnic minorities.

In addition to other built environment attributes, residents' perceptions of other neighborhood factors, like safety and aesthetics, could be measured and compared to actual or audited neighborhood factors and associated to BMI, body fat and PA. Although our study did not aim to measure these factors, other individual cultural and psychological individual variables could be included. Including these additional variables might help to explain variance of attribute perceptions and if particular individual characteristics affect perceptions about neighborhood attributes and PA adoption.

We did recruit participants from two metropolitan areas. More study is needed to compare directly and indirectly measured environmental data in different geographical areas and measure the effect(s) concordance has on PA adoption in various areas. More data are needed that clarifies specific built environment attributes important for health behaviors and whether accurate perceptions of these attributes are necessary. Further, revisions of current Ecological models related to PA may be needed as their generalizability might be limited with population subgroups. Our results do not support current frameworks, suggesting that certain built environment attributes might not affect PA adoption among minority women. Although the influence of the built environment on individual health behaviors has been well established, more study of the linkages, processes and interactions of specific built environment attributes and intra-individual factors like gender and ethnicity is needed. When measuring the built environment, researchers must consider the associations between directly and indirectly measured neighborhood data, weight status and PA, particularly among the highly vulnerable population of minority women.

Limitations

Due to retention and logistic reasons, the number of participants who wore an accelerometer was significantly fewer than those who completed the IPAQ questionnaire. Future studies should attempt to recruit and assess an equal number of participants for both PA measures to provide a more comprehensive PA assessment. Although we did not seek to measure PA performed within the built environment, we cannot be certain that collected PA data was performed within the participant's built environment. Future concordance studies could assess the types and amounts of PA completed within specific features of the built environment, particularly those neighborhood attributes being measured and associated to perceptions.

We also had significantly more AA than HL women. Future studies comparing different ethnicities could attempt to employ more equal sample sizes, in order to increase generalizability and comparison. Although not planned, most participants were of higher SES. Residents could have self-selected their neighborhoods, having more means to do so, therefore having positive perceptions about their neighborhoods' PA options. More study is needed for populations of varying SES levels. Our study did not intend to compare built environment attributes and PA levels between two different cities, but we did recruit participants from two metropolitan areas. These two different areas could have affected concordance and PA adoption in this study, although both cities were located within the same state and had similar built environment features.

CHAPTER 6

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Appendix A

(Direct and Indirect Environmental Measures, IPAQ-Long Form)

Physical Activity Resource Assessment Instrument (PARA)

1) **Date** ____________
4) **Time**
start:_____
stop:_____

2) **Data col** ____
5) **Phone Call**
arrival: ☐
departure: ☐

3) **HD/PA Resource ID** __________

6) **Type of Resource**
1 fitness club **2** park
3 sport facility **4** trail
5 community center **6** church
7 school
8 combination ________________

7) **Approximate Size:** **1** sm **2** med **3** lg

8) **Capacity (indoor)** ____________

9) **Cost**
1 Free
2 Pay at the door
3 Pay for only certain programs
4 Other ____________________

10) **Hours** a) open ______ b) close ______

11) **Signage** – Hours yes ☐ no ☐

12) **Signage** – Rules yes ☐ no ☐

Feature	**Rating**				**Amenity**	**Rating**			
13) Baseball field	0	1	2	3	26) Access Points	0	1	2	3
14) BB courts	0	1	2	3	27) Bathrooms	0	1	2	3
15) Soccer field	0	1	2	3	28) Benches	0	1	2	3
16) Bike Rack	0	1	2	3	29) Drinking fountain	0	1	2	3
17) Exercise Stations	0	1	2	3	30) Fountains	0	1	2	3
18) Play equipment	0	1	2	3	31) Landscaping efforts	0	1	2	3
19) Pool > 3 ft deep	0	1	2	3	32) Lighting	0	1	2	3
20) Sandbox	0	1	2	3	33) Picnic tables shaded	0	1	2	3
21) Sidewalk	0	1	2	3	34) Picnic tables no-shade	0	1	2	3
22) Tennis courts	0	1	2	3	35) Shelters	0	1	2	3
23) Trails – running/biking	0	1	2	3	36) Shower/Locker room	0	1	2	3
24) VB courts	0	1	2	3	37) Trash containers	0	1	2	3
25) Wading Pool < 3 ft.	0	1	2	3					

Incivilities	**Rating**				**Incivilities**	**Rating**			
38) Auditory annoyance	0	1	2	3	44) Graffiti/tagging	0	1	2	3
39) Broken glass	0	1	2	3	45) Litter	0	1	2	3
40) Dog refuse	0	1	2	3	46) No grass	0	1	2	3
41) Dogs Unattended	0	1	2	3	47) Overgrown grass	0	1	2	3
42) Evidence of alcohol use	0	1	2	3	48) Sex paraphernalia	0	1	2	3
43) Evidence of substance use	0	1	2	3	49) Vandalism	0	1	2	3

Comments:

UNDO Projects 2005*Dr. Rebecca Lee, Principal Investigator*releephd@yahoo.com

Assessor Name: ____________ **Date:** ____________ **Time:** ____________ PEDS

Participant ID : ____________ **Street segment ID:** ____________ **Weather:** ____________

0. Segment type
- Low volume road 1
- High volume road 2
- Bike or Ped path - skip section C 3

A. Environment

1. Uses in Segment *(all that apply)*
- Housing - Single Family Detached 1
- Housing - Multi-Family 2
- Housing - Mobile Homes 3
- Office/Institutional 4
- Restaurant/Café/Commercial 5
- Industrial 6
- Vacant/Undeveloped 7
- Recreation 8
- Surface parking lot 9
- School 10
- Areas of worship 11

2. Slope
- Flat 1
- Slight hill 2
- Steep hill 3

3. Segment Intersections
- Dead ends 1
- Segment continues 2
- Road ends, path continues 3

B. Pedestrian Facility *(skip if none present)*

4. Type(s) of pedestrian facility *(all that apply)*
- Footpath (worn dirt path) 1
- Paved Trail 2
- Sidewalk 3
- Pedestrian Street (closed to cars) 4
- None (skip to section C) 5

The rest of the questions in section B refer to the best pedestrian facility selected above.

5. Path material *(all that apply)*
- Asphalt 1
- Concrete 2
- Paving Bricks or Flat Stone 3
- Gravel 4
- Dirt or Sand 5

6. Path condition/maintenance
- Poor (many bumps/cracks/holes) 1
- Fair (some bumps/cracks/holes) 2
- Good (very few bumps/cracks/holes) 3
- Under Repair 4

7. Path obstructions *(all that apply)*
- Poles or Signs 1
- Parked Cars 2
- Trees 3
- Garbage Cans 4
- Other 5
- None 6

8. Buffers between road and path *(all that apply)*
- Fence 1
- Trees 2
- Hedges 3
- Landscape 4
- Grass 5
- None 6

9. Path Distance from Curb
- At edge 1
- < 5 feet 2
- > 5 feet 3

10. Path Width
- < 4 feet 1
- Between 4 and 8 feet 2
- > 8 feet 3

If no sidewalk,skip now to section C.

11. Curb cuts
- None 1
- 1 to 4 2
- > 4 3

12. Path completeness/continuity
- Path is complete 1
- Path is incomplete 2

13. Path connectivity to otherpaths
- number of connections _____ 1

C. Road Attributes *(skip if no road is present/path only)*

14. Condition of road
- Poor (many bumps/cracks/holes) 1
- Fair (some bumps/cracks/holes) 2
- Good (very few bumps/cracks/holes) 3
- Under Repair 4

15. Number of travel lanes _____ 1

16. Posted regular speed limit
- None posted 1
- (mph): _____ 1

17. On-Street parking *(if pavement is unmarked and no cars are parked, look for no parking signs to verify 'none')*
- Parellel 1
- Diagonal 2
- None 3

18. Off-street parking lot spaces

0-5	6-25	26+
1	2	3

19. Must you walk through a parking lot to get to most buildings?
- Yes 1
- No 2

20. Presence of med-hi volume driveways
- < 2 1
- 2 to 4 2
- > 4 3

21. Traffic control devices *(all that apply)*
- Traffic light 1
- Stop sign 2
- Traffic circle 3
- Speed humps/bumps 4
- Mid-block island/chicanes/chokers 5
- None 6

22. Crosswalks
- None 1
- 1 to 2 2
- 3 to 4 3
- > 4 4

23. Crossing Aids *(all that apply)*
- Yield to Ped Paddles 1
- Pedestrian Signal 2
- Median/Traffic Island 3
- Curb Extension 4
- Overpass/Underpass 5
- Pedestrian Crossing Warning Sign 6
- Flashing Warning Light 7
- Share the road warning sign 8
- None

24. Bicycle facilities *(all that apply)*
- Bicycle route signs 1
- Striped bicycle lane designation 2
- Visible bicycle parking facilities 3
- Bicycle crossing warning 4
- No bicycle facilities 5

D. Walking/Cycling Environment

25. Roadway/path lighting
- Road-oriented lighting 1
- Pedestrian-scale lighting 2
- Other lighting 3
- No lighting 4

26. Amenities *(all that apply)*
- Public garbage cans 1
- Benches 2
- Water fountain 3
- Street vendors/vending machines 4
- No amenities 5

27. Check if any wayfinding aids present
- No 1
- Yes 2

28. Number of trees shading walking area
- None 1
- Some 2
- Many/Dense 3

29. Degree of enclosure
- No enclosure 1
- Some enclosure 2
- Highly enclosed 3

30. Powerlines along segment?
- Low Voltage/Distribution Line 1
- High Voltage/Transmission Line 2
- None 3

31. Overall street cleanliness & building maintenance
- Poor (much litter/graffiti/broken facilities) 1
- Fair (some litter/graffiti/broken facilities) 2
- Good (no litter/graffiti/broken facilities) 3

32. Articulation in building designs
- No buildings 0
- Little or no articulation 1
- Some articulation 2
- Highly articulated 3

33. Building setbacks from path
- No path 0
- At edge of path 1
- Within 20 feet of path 2
- More than 20 feet from path 3

34. Building height (all that apply)
- No buildings 0
- 1 story 1
- 2-5 stories 2
- > 5 stories 3

35. Bus stops
- Bus stop with shelter 1
- Bus stop with bench 2
- Bus stop with signage only 3
- No bus stop 4

Subjective Assessment: Segment...

1=Strongly Agree 2= Agree,
3=Disagree, 4=Strongly Disagree

- ......is attractive for walking. _____ 1
- ......is attractive for cycling. _____ 1
- ......feels safe for walking. _____ 1
- ......feels safe for cycling. _____ 1

Kelly J. Clifton, PhD - National Center for Smart Growth - University of Maryland, College Park ; modified by Tracy E. McMillan, Ph.D., MPH - University of Texas at Austin; 2/27/07

Comments: ____________________ E________ P________

International Physical Activity Prevalence Study
SELF-ADMINISTERED ENVIRONMENTAL MODULE

There is increasing interest in the contextual (environmental) barriers that prevent or limit the opportunity to walk and cycle in areas around where we live and work. Factors that are emerging as important include land use, housing density, accessibility to public transport systems, and perceived safety from traffic and crime. Research in this field is still in its infancy and many other factors are also being researched. Moreover currently there are very few well-developed survey instruments addressing this topic.

The International Physical Activity Prevalence Study (IPS) has developed an optional ENVIRONMENTAL MODULE that can be used to assess the environmental factors for walking and bicycling in your neighborhoods. We offer it for use in the IPS Study *in addition to the IPAQ (short form)*. Countries participating in IPS are encouraged to consider ways in which they can extend their participation and study protocols to include the optional ENVIRONMENTAL MODULE.

The ENVIRONMENTAL MODULE has three sets of carefully chosen items that reflect current thinking in this field and in which the reliability and validity of each item has been assessed. We tried to keep the module as short as possible, include the variables that have already shown to be associated with different levels of activity in different countries, and select items that would be of interest and relevant to all countries regardless of the stage of economic development.

The three sets of items re grouped as follows:

CORE (Items 1-7)
RECOMMENDED (Items 8-11)
OPTIONAL (Items 12-17)

All countries that use the ENVIRONMENTAL MODULE *must* ask all CORE items. We encourage you to ask as many RECOMMENDED items as possible. If you have space in your survey and if you are interested in the environmental aspects of physical activity, we provide a small set of OPTIONAL items for use. If your country is able to add more questions on different aspects of the environment than provided here, we can provide other tested items (not shown here) and would be willing to help you make a selection.

We recognize it is unlikely that all the items (CORE, RECOMMENDED AND OPTIONAL) will be asked in a country.

Please note - The wording of items and the response scales should not be changed because this will most likely change the meaning of the questions and prohibit comparison between countries. The relevancy and responses to items will vary greatly across countries, so it is critical to document national differences. We provide guidelines at the end of the survey for the translation process and cultural adaptation to make the items relevant to your country and the language spoken.

INTERNATIONAL PREVALENCE STUDY [IPS] ON PHYSICAL ACTIVITY

Think about the different facilities in and around your neighborhood by this we mean the area ALL around your home that you could walk to in **10-15 minutes**.

1. What is the main type of housing in your neighborhood?

   1 ☐ Detached single-family housing

   2 ☐ Townhouses, row houses, apartments, or condos of 2-3 stories

   3 ☐ Mix of single-family residences and townhouses, row houses, apartments or condos

   4 ☐ Apartments or condos of 4-12 stories

   5 ☐ Apartments or condos of more than 12 stories

   77 ☐ Don't know/Not sure

The next items are statements about your neighborhood related to walking and bicycling.

2. Many shops, stores, markets or other places to buy things I need are within easy walking distance of my home. Would you say that you…

   1 ☐ Strongly disagree

   2 ☐ Somewhat disagree

   3 ☐ Somewhat agree

   4 ☐ Strongly agree

   77 ☐ Don't know/Not sure

3. It is within a 10-15 minutes walk to a transit stop (such as bus, train, trolley, or tram) from my home. Would you say that you…

   1 ☐ Strongly disagree

   2 ☐ Somewhat disagree

   3 ☐ Somewhat agree

   4 ☐ Strongly agree

   77 ☐ Don't know/Not sure

4. There are sidewalks on most of the streets in my neighborhood. Would you say that you…

- 1 ☐ Strongly disagree
- 2 ☐ Somewhat disagree
- 3 ☐ Somewhat agree
- 4 ☐ Strongly agree
- 88 ☐ Does not apply to my neighborhood
- 77 ☐ Don't know/Not sure

5. There are facilities to bicycle in or near my neighborhood, such as special lanes, separate paths or trails, shared use paths for cycles and pedestrians. Would you say that you…

- 1 ☐ Strongly disagree
- 2 ☐ Somewhat disagree
- 3 ☐ Somewhat agree
- 4 ☐ Strongly agree
- 88 ☐ Does not apply to my neighborhood
- 77 ☐ Don't know/Not sure

6. My neighborhood has several **free** or **low cost** recreation facilities, such as parks, walking trails, bike paths, recreation centers, playgrounds, public swimming pools, etc. Would you say that you…

- 1 ☐ Strongly disagree
- 2 ☐ Somewhat disagree
- 3 ☐ Somewhat agree
- 4 ☐ Strongly agree
- 77 ☐ Don't know/Not sure

7. The crime rate in my neighborhood makes it unsafe to go on walks at night. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

8. There is so much traffic on the streets that it makes it difficult or unpleasant to walk in my neighborhood. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
88 ☐ There are no streets or roads in my neighborhood
77 ☐ Don't know/Not sure

9. I see many people being physically active in my neighborhood doing things like walking, jogging, cycling, or playing sports and active games. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

10. There are many interesting things to look at while walking in my neighborhood. Would you say you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

11. How many motor vehicles in working order (e.g., cars, trucks, motorcycles) are there at your household?

____ Motor Vehicles
77 ☐ Don't know/Not sure

12. There are many four-way intersections in my neighborhood. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
88 ☐ There are no streets or roads in my neighborhood
77 ☐ Don't know/Not sure

13. The sidewalks in my neighborhood are well maintained (paved, with few cracks) and not obstructed. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

14. Places for bicycling (such as bike paths) in and around my neighborhood are well maintained and not obstructed. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

15. There is so much traffic on the streets that it makes it difficult or unpleasant to ride a bicycle in my neighborhood. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

16. The crime rate in my neighborhood makes it unsafe to go on walks during the day. Would you say that you…

1 ☐ Strongly disagree
2 ☐ Somewhat disagree
3 ☐ Somewhat agree
4 ☐ Strongly agree
77 ☐ Don't know/Not sure

17. There are many places to go within easy walking distance of my home. Would you say that you…

- 1 ☐ Strongly disagree
- 2 ☐ Somewhat disagree
- 3 ☐ Somewhat agree
- 4 ☐ Strongly agree
- 77 ☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE
(October 2002)

LONG LAST 7 DAYS SELF-ADMINISTERED FORMAT

FOR USE WITH YOUNG AND MIDDLE-AGED ADULTS (15-69 years)

The International Physical Activity Questionnaires (IPAQ) comprises a set of 4 questionnaires. Long (5 activity domains asked independently) and short (4 generic items) versions for use by either telephone or self-administered methods are available. The purpose of the questionnaires is to provide common instruments that can be used to obtain internationally comparable data on health–related physical activity.

Background on IPAQ

The development of an international measure for physical activity commenced in Geneva in 1998 and was followed by extensive reliability and validity testing undertaken across 12 countries (14 sites) during 2000. The final results suggest that these measures have acceptable measurement properties for use in many settings and in different languages, and are suitable for national population-based prevalence studies of participation in physical activity.

Using IPAQ
Use of the IPAQ instruments for monitoring and research purposes is encouraged. It is recommended that no changes be made to the order or wording of the questions as this will affect the psychometric properties of the instruments.

Translation from English and Cultural Adaptation
Translation from English is encouraged to facilitate worldwide use of IPAQ. Information on the availability of IPAQ in different languages can be obtained at www.ipaq.ki.se. If a new translation is undertaken we highly recommend using the prescribed back translation methods available on the IPAQ website. If possible please consider making your translated version of IPAQ available to others by contributing it to the IPAQ website. Further details on translation and cultural adaptation can be downloaded from the website.

Further Developments of IPAQ
International collaboration on IPAQ is on-going and an ***International Physical Activity Prevalence Study*** is in progress. For further information see the IPAQ website.

More Information

More detailed information on the IPAQ process and the research methods used in the development of IPAQ instruments is available at www.ipaq.ki.se and Booth, M.L. (2000). *Assessment of Physical Activity: An International Perspective.* Research Quarterly for Exercise and Sport, 71 (2): s114-20. Other scientific publications and presentations on the use of IPAQ are summarized on the website.

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** and **moderate** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal.

PART 1: JOB-RELATED PHYSICAL ACTIVITY

The first section is about your work. This includes paid jobs, farming, volunteer work, course work, and any other unpaid work that you did outside your home. Do not include unpaid work you might do around your home, like housework, yard work, general maintenance, and caring for your family. These are asked in Part 3.

1. Do you currently have a job or do any unpaid work outside your home?

☐

Yes

☐ No ➡ ***Skip to PART 2: TRANSPORTATION***

The next questions are about all the physical activity you did in the **last 7 days** as part of your paid or unpaid work. This does not include traveling to and from work.

2. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, heavy construction, or climbing up stairs **as part of your work**? Think about only those physical activities that you did for at least 10 minutes at a time.

_____ **days per week**

☐ No vigorous job-related physical activity ➡ ***Skip to question 4***

3. How much time did you usually spend on one of those days doing **vigorous** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

4. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads **as part of your work**? Please do not include walking.

_____ **days per week**

☐ No moderate job-related physical activity → ***Skip to question 6***

5.How much time did you usually spend on one of those days doing **moderate** physical activities as part of your work?

_____ **hours per day**

_____ **minutes per day**

6. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **as part of your work**? Please do not count any walking you did to travel to or from work.

_____ **days per week**

☐ No job-related walking → ***Skip to PART 2: TRANSPORTATION***

7. How much time did you usually spend on one of those days **walking** as part of your work?

_____ **hours per day**

_____ **minutes per day**

PART 2: TRANSPORTATION PHYSICAL ACTIVITY

These questions are about how you traveled from place to place, including to places like work, stores, movies, and so on.

8. During the **last 7 days**, on how many days did you **travel in a motor vehicle** like a train, bus, car, or tram?

_____ **days per week**

☐ No traveling in a motor vehicle ➞ ***Skip to question 10***

9. How much time did you usually spend on one of those days **traveling** in a train, bus, car, tram, or other kind of motor vehicle?

_____ **hours per day**

_____ **minutes per day**

Now think only about the **bicycling** and **walking** you might have done to travel to and from work, to do errands, or to go from place to place.

10. During the **last 7 days**, on how many days did you **bicycle** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No bicycling from place to place ➞ ***Skip to question 12***

11. How much time did you usually spend on one of those days to **bicycle** from place to place?

_____ **hours per day**

_____ **minutes per day**

12. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time to go **from place to place**?

_____ **days per week**

☐ No walking from place to place ➞ ***Skip to PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY***

13. How much time did you usually spend on one of those days walking from place to place?

_____ **hours per day**

_____ **minutes per day**

PART 3: HOUSEWORK, HOUSE MAINTENANCE, AND CARING FOR FAMILY

This section is about some of the physical activities you might have done in the **last 7 days** in and around your home, like housework, gardening, yard work, general maintenance work, and caring for your family.

14. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, chopping wood, shoveling snow, or digging **in the garden or yard**?

_____ **days per week**

☐ No vigorous activity in garden or yard → ***Skip to question 16***

15. How much time did you usually spend on one of those days doing **vigorous** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

16. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, sweeping, washing windows, and raking **in the garden or yard**?

_____ **days per week**

☐

No moderate activity in garden or yard → ***Skip to question 18***

17. How much time did you usually spend on one of those days doing **moderate** physical activities in the garden or yard?

_____ **hours per day**

_____ **minutes per day**

18. Once again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** activities like carrying light loads, washing windows, scrubbing floors and sweeping **inside your home**?

_____ **days per week**

☐ No moderate activity inside home → ***Skip to PART 4: RECREATION, SPORT AND LEISURE-TIME PHYSICAL ACTIVITY***

19. How much time did you usually spend on one of those days doing **moderate** physical activities inside your home?

_____ **hours per day**

_____ **minutes per day**

PART 4: RECREATION, SPORT, AND LEISURE-TIME PHYSICAL ACTIVITY

This section is about all the physical activities that you did in the **last 7 days** solely for recreation, sport, exercise or leisure. Please do not include any activities you have already mentioned.

20. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time **in your leisure time**?

_____ **days per week**

☐ No walking in leisure time → ***Skip to question 22***

21. How much time did you usually spend on one of those days **walking** in your leisure time?

_____ **hours per day**

_____ **minutes per day**

22. Think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **vigorous** physical activities like aerobics, running, fast bicycling, or fast swimming **in your leisure time**?

_____ **days per week**

☐ No vigorous activity in leisure time → ***Skip to question 24***

23. How much time did you usually spend on one of those days doing **vigorous** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

24. Again, think about only those physical activities that you did for at least 10 minutes at a time. During the **last 7 days**, on how many days did you do **moderate** physical activities like bicycling at a regular pace, swimming at a regular pace, and doubles tennis **in your leisure time**?

_____ **days per week**

☐ No moderate activity in leisure time → ***Skip to PART 5: TIME SPENT SITTING***

25. How much time did you usually spend on one of those days doing **moderate** physical activities in your leisure time?

_____ **hours per day**

_____ **minutes per day**

PART 5: TIME SPENT SITTING

The last questions are about the time you spend sitting while at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading or sitting or lying down to watch television. Do not include any time spent sitting in a motor vehicle that you have already told me about.

26. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

_____ **hours per day**

_____ **minutes per day**

27. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekend day**?

_____ **hours per day**

_____ **minutes per day**

This is the end of the questionnaire, thank you for participating.