Latent Growth Modeling of a Nutrition and Physical Activity Intervention

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LATENT GROWTH MODELING OF A NUTRITION AND PHYSICAL ACTIVITY INTERVENTION

by

Alicia Dea Sample

Abstract of a Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

August 2011
ABSTRACT

LATENT GROWTH MODELING OF A NUTRITION AND PHYSICAL ACTIVITY INTERVENTION

by Alicia Dea Sample

August 2011

The health, economic, and social impacts of physical inactivity and unhealthy dietary patterns are quite significant and evidenced by the fact that only 3-4% of American adults follow all the dietary advice recommended by the Dietary Guidelines for Americans (DGA; Kohatsu, Robinson, & Torner, 2004), and specific subpopulations, including the rural South, are affected even more drastically (McCabe-Sellers et al., 2007). Furthermore, the majority of the people in the United States do not currently meet recommended amounts of physical activity (PA) and have not since the mid 1980s (U.S. Department of Health and Human Services [USDHHS], 2008). To address the discrepancy between health recommendations and actualized unhealthy patterns of physical activity and diet, community members in a small, urban area composed of a racially diverse population in Mississippi collaborated with university researchers to develop a community partnership that was named H.U.B. City Steps.

The primary purpose of the present study was to use latent growth modeling (LGM) to determine relationships between latent variables and examine factors that not only prompt healthy behavior changes but allow for individual behavior maintenance within the H.U.B. City Steps sample. A secondary analysis used a structural equation
model (SEM) to test interrelationships of variables that have been theorized to impact blood pressure.

The LGM was unsuccessfully executed while the SEM revealed that none of the paths leading to systolic blood pressure (SBP) were significant. In the SEM, while the paths to SBP were not significant, significant relationships demonstrated between SES and the psychosocial latent variable as well as SES and physiologic variables in this primarily African American population are of interest. A model encompassing an individual’s past health in conjunction with factors reflecting the cultural, social, and community context in which the individual is seated could be used to inform future interventions.

Future research could examine the pathways of individual characteristics that form behaviors and then how the behaviors formed lead to health outcomes. The current LGM assessed individual factors and sought to predict relationships directly to health outcomes, but perhaps a more effective analysis might be to use health behaviors as the dependent variable and test health outcomes independently.

While the primary analysis was unsuccessful, the research described herein is quite valuable. Future researchers need guidance as to how to approach conceptualizing and testing latent variables that are related to health behaviors. Furthermore, successful approaches, as well as unsuccessful modeling attempts, should be openly discussed for the benefit of future analysis.
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A Dissertation
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LIST OF ABBREVIATIONS

AGFI: Adjusted Goodness of Fit Index
BCC: Behavior Change Consortium
BMI: Body Mass Index
BRFSS: Behavioral Risk Factor Surveillance System
CBPR: Community Based Participatory Research
CDC: Center for Disease Control
CFA: Confirmatory Factor Analysis
CFI: Comparative Fit Index
CPR: Cardiopulmonary Resuscitation
CVD: Cardiovascular Disease
DASH: Dietary Approaches to Stop Hypertension
DGA: Dietary Guidelines for Americans
DPP: Diabetes Prevention Program
FFQ: Food Frequency Questionnaire
FIML: Full Information Maximum Likelihood
GFI: Goodness of Fit Index
HDL: High Density Lipoprotein
HLM: Hierarchical Linear Modeling
IOM: Institute of Medicine
IPAQ: International Physical Activity Questionnaire
LDL: Low Density Lipoprotein
LGM: Latent Growth Model
LPI: Leadership Practices Inventory
MI: Motivational Interviewing
MLM: Multi-level Modeling
NCI: National Cancer Institute
NHANES: National Health and Nutrition Examination Survey
NIH: National Institutes of Health
PA: Physical Activity
PASS: Physical Activity Social Support
POC: Processes of Change
RMSEA: Root Mean Square Error of Approximation
RWJF: Robert Wood Johnson Foundation
SBP: Systolic Blood Pressure
SCT: Social Cognitive Theory
SEM: Structural Equation Model
SES: Socioeconomic Status
TLI: Tucker-Lewis Index
TSRD: Treatment Self-Regulation Diet
TSRPA: Treatment Self-Regulation Physical Activity
TTM: Transtheoretical Model
USDHHS: United States Department of Health and Human Services
WC: Waist Circumference
CHAPTER I
INTRODUCTION

The economic and social impacts of physical inactivity are quite significant. The majority of the people in the United States do not currently meet recommended amounts of physical activity (PA) and have not since the mid 1980s (U.S. Department of Health and Human Services [USDHHS], 2008). As far back as 1961, publications were emerging from the Framingham Heart Study about cardiovascular disease (CVD) risk factors in relation to diet (Kannel et al., 1961; Mann, Pearson, Gordon, & Dawber, 1962) and in 1967 PA was found to reduce the risk of heart disease and obesity as well as lack of PA to increase the risk of CVD (Kannel, 1967). Then, in 1996, the National Institutes of Health (NIH) further illustrated the importance of the link between physical inactivity to premature CVD, obesity, diabetes, orthopedic problems, and emotional distress (NIH Consensus Development Panel on Physical Activity and Cardiovascular Health, 1996). More recently, the World Health Organization (WHO) has indicated that CVDs are the leading cause of death globally (WHO, 2003) and the American College of Sports Medicine (ACSM) and American Heart Association (AHA) stated that adults who engage in even 30 minutes of moderate PA five days per week will optimize health outcomes (ACSM, 2008). The importance of PA for physical and mental health is well documented.

Despite the knowledge regarding the preventive effects PA has on CVD and other chronic disease risk factors, Americans are still dying from this disease at an inordinate rate. Specifically, the leading death rates from CVD in 2005 were found in Mississippi (270.9 per 100,000) which in effect makes the mortality rate 25% higher than
that of the United States (US) as a whole. Additionally, The Centers for Disease Control and Prevention (CDC), National Center for Health Statistics (2009), stated that Mississippi had the highest rates of adult obesity (67%).

Lifestyle plays an important role in the development of chronic disease and data indicate that most US adults do not meet current guidelines considered to be preventive behaviors related to living a healthy lifestyle. The 2008, U.S. Guidelines for Physical Activity recommend 2 hours and 30 minutes (150 minutes total) of moderate-intensity PA a week for general health maintenance and 3 hours and 20 minutes (180 minutes total) for added benefits, including weight loss (USDHHS, 2008). Given this, only half of U.S. adults meet the first recommendation of 150 minutes per week (CDC, 2005a).

It has been known for more than a decade that physical inactivity rates are highest among women, minorities, and lower socioeconomic groups (USDHHS, 1996). Socioeconomic status (SES) is defined as a person’s societal status using factors or measurements such as income levels, educational achievement, neighborhood of residence, or home ownership. Unfortunately, greater health disparities are seen in populations with lower SES and among minority populations. In 2007, African Americans were 50% less likely to engage in PA than Non-Hispanic Whites, and deaths from heart disease and stroke were almost twice the rate for African Americans as compared to Whites (CDC, 2009). A systematic review published in 2009 (Whitt-Glover & Kumanyika, 2009) included articles from 1985-2006 that reported data about fitness behavior change in African Americans. Forty-three articles were identified as being relevant. Studies were then ranked for study quality based on the following characteristics: degree of focus on PA, inclusion of PA goals in the intervention, PA
assessments, and cultural adaptation. The authors reported that among all studies, there were modest short and long term successes for improving levels of PA in African Americans. The highest ranking studies among all age groups were those that had a randomized control trial design and specific goals targeting PA. Those with high quality scores also showed within and between group effects for increases in PA. The authors stated that because so few long term data were available, there would be no way to make inferences regarding the long term effects of these PA interventions with African Americans. There were many approaches to increasing PA, but few focused on behavior change despite a large volume of literature that has suggested employing behavior change techniques may be a promising way to increase PA.

While many interventions have attempted to ascertain the underlying mechanisms by which behavior can be changed, and multiple PA interventions have incorporated behavior change theories in their development, these studies have not focused on understanding the mechanisms of change, nor have they used a multidisciplinary perspective to understand the process. Understanding the psychosocial, environmental, and physiological factors that affect the mechanisms of behavior change is necessary for developing effective interventions. It is imperative to target correlates that are in the causal pathways of PA behavior change and not waste time on resources and interventions that deal with variables not directly related to PA behavior change (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001). Given the importance of PA in the etiology, treatment, and prevention of many chronic diseases (such as CVD, some cancers, and diabetes), it is important to understand how PA intention, performance, and behavior can be increased. Thus, an increased understanding of the mediators (a variable
that explains the relationship between other variables) by which PA interventions are effective can provide feedback that can lead to systematic improvements in intervention efficacy and efficiency. Furthermore, better understanding of PA intervention moderators (a variable that influences the strength of a relationship between other variables) can help tailor interventions to specific subgroups and investigation of confounders can lead to more accurate interpretations about causal effects of interventions.

In essence, the body of literature reporting on PA interventions reports methods to produce short term behavior change, but factors promoting sustainability of behavior change seem somewhat elusive, and thus scientific advancement related to design of research or public health interventions to increase PA has not progressed as efficiently as possible. Researchers, as well as public and private agencies and organizations, can continue to develop and carryout PA interventions but until PA behaviors are improved and sustained, society will be adversely impacted by sedentary behavior. The purpose of this research was to examine the factors that not only prompt healthy behavior changes but allow for individual behavior maintenance and establishment of social policies that encourage healthier, physically active communities.

Description of H.U.B. City Steps

For the reasons described above, community members in a small, urban area composed of a racially diverse population in Mississippi were invited to collaborate with University researchers to develop a community partnership in which a PA intervention would be developed. From this partnership, a walking intervention program was planned by collaborators, with feedback from a community advisory board who suggested the intervention be named H.U.B. City Steps. Three specific aims of the research were
developed and included capacity building (to develop and assess community capacity to promote PA and healthy food choices), intervention (to test treatment effects on health indicators such as systolic blood pressure (SBP) and other biological and anthropometric variables among all walking participants), and maintenance (to test the treatment effects of a sustained motivational enhancement via telephone on SBP and other health indicators). Additionally, other details of the 6-month walking intervention included improving PA and health through membership in walking teams led by supportive coaches, active promotion of self-monitoring via pedometers and walking logs, and monthly nutrition and PA educational sessions (Zoellner et al., 2011).

As alluded to previously, the H.U.B. City Steps intervention community based participatory research (CBPR) precepts and dimensions included the establishment of community committees, recruitment and training of volunteer leaders who recruited friends and neighbors to participate in walking groups, assessment of participants to evaluate health improvements associated with walking, and continuous process evaluation to ensure that intervention components were delivered as planned and adverse issues were addressed. The overall project period has been defined as from July 1, 2008 - June 30, 2013. Year 1 was designated for establishment of committees, hiring personnel, recruiting volunteer leaders, preparing manuals of procedure, and assessing the community walking environment. The second year included recruiting participants and implementing the walking intervention as well as its component parts. The Intervention staff included an intervention coordinator as well as assessment and evaluation personnel, a coach coordinator and a recruitment coordinator. The goal of the outcome data collection for the H.U.B. City Steps program was to assess changes in physical, dietary,
and psychosocial outcome measures in program participants every three months following baseline data collection and up to month six, the point of randomization.

Analytical Approach

Many studies have examined the predictive ability of consuming certain foods or performing certain activities in relation to sedentary lifestyle or obesity. These studies typically use a form of regression to assign probabilities to certain groups. Multiple regression analysis is limited by several assumptions that PA and food frequency data often do not meet; for example, linearity and normality. Linearity is a specific concern for this type of data as linear relationships predict constant change when in fact health behaviors may follow a more time dependent change in which change trajectories are very informative. For example, in the case of an intervention like H.U.B. City Steps, greater change in outcome measures may be seen earlier in the course of the intervention compared to later in the intervention. Furthermore, current research suggests that no single factor can predict PA behavior and the use of ecological approaches is becoming increasingly popular. These comprehensive approaches are seeking to incorporate interpersonal, intrapersonal, environmental, and policy factors to increase overall understanding about how to address changes in PA and nutrition related behaviors. The research presented herein tested a model developed from variables consistent with theory and previous research to better identify health behaviors and physiologic characteristics that predict changes in health outcomes, with the help of a PA intervention, over time.

Relationships among socioeconomic factors, lifestyle factors, and health histories are often examined through multivariate regression techniques and while this provides insight into independent associations among pairs of variables it does not allow for direct
and indirect effects to be accounted for properly. Latent growth modeling (LGM) was used to test systematic intraindividual and interindividual differences in measures over multiple time points and identify change in theory driven variables over time (Duncan, Duncan, Strycker, Li & Alpert, 1999; Muthén, 1997). In essence, this research attempted to identify the extent to which individuals change in a given timeframe (intraindividual), as well as examined the patterns of and differences in changes over time among the cohort (interindividual) Stull, 2008). The analytical approach is described below in order to frame the research questions in the context of this LGM analytical framework.

Few examples of LGM have been published in the area of nutrition and PA, and despite the fact that LGM is simply an extension of structural equation modeling (SEM), SEM has been reported much more frequently than LGM in recent years (Ball, Crawford & Mishra, 2005; McNeil, Wyrwich, Brownson, Clark, & Kreuter, 2006; Nies & Sun, 2008; Rovniak, Anderson, Winett, & Stephens, 2002). Likewise, the Institute of Medicine (IOM) Report on Physical Activity indicates that little research has been conducted to actually examine the mediating and moderating effects of environments and other contextual factors (Committee on Physical Activity, Transportation and Land Use, 2005). An advantage to using LGM over SEM is that longitudinal data can be more thoroughly examined and LGM is a more precise predictor of probability (Muthen, 1997).

Latent variable modeling, including LGM, estimates change over time by focusing on the repeated measures indirectly, as opposed to the direct observation of the means in analysis (Duncan et al., 1999). Latent growth curve models can also be thought of as multilevel models (MLM), with the variable of time as a level one variable and the
intercept the predicted value when time is zero. Continuing the comparison to MLM, each subject has a different intercept and slope, expressed as random effects at level two. LGM allows for the examination of dynamic associations of behavior over time, rather than a static view of behavior as examined at one time point. Specific types of LGM (i.e., associative or multivariate LGM) allow one to determine the extent to which the trajectories of certain behaviors are interrelated. Finally, LGM allows the researcher to determine if there are multiple populations rather than a single population (measurement invariance), as well as multiple developmental pathways rather than a single underlying pathway for all individuals (Loehlin, 1992).

Research Objectives

1. Specify the observed variables that comprise the latent variables “Psychosocial,” “Health Indicator,” and “Socioeconomic Status.”

2. Investigate relationships among the latent variables psychosocial, health indicator, and socioeconomic status.

3. Examine the latent variables’ (psychosocial, health indicator, and socioeconomic status) impact on participants’ intervention-related change over time (slope and intercept of the LGM).
Research Hypotheses

1. The presence of poor health at baseline, as measured by the self-reported health status variable, will increase the slope (growth trajectory) of the health indicator at months three and six. The increase in growth trajectory is a reflection of improvement in health status as evidenced by the latent variable health indicator.

2. Individuals with a low diet quality factor, as indicated by the “Food Frequency” variable, will decrease the growth trajectory or, see less improvement in health status, as evidenced by the health indicator at months three and six in relation to individuals with a high diet quality factor.

3. High SES participants will increase the growth trajectory of or, see greater improvement in, health status as evidenced by the health indicator at months three and six compared to those participants with lower SES.

4. Individuals assigned to a coach with a higher coach score will exhibit increased growth trajectories or, see greater improvement in, health status as evidenced by the health indicator at months three and six compared to those assigned to coaches with lower coach scores.

5. Participants in behavioral stages, as indicated by the psychosocial latent variable, will have increased growth trajectories or see greater improvement in health status as evidenced by health indicator at months three and six compared to those who are in the experiential phase.

6. Growth trajectories, or pathways, will exhibit differing growth patterns (non-linear) as evidenced by differing changes in health status as evidenced by the health indicator from zero to three months than from three to six months.
Assumptions

This research is a secondary analysis of data collected as part of the H.U.B. City Steps walking intervention. The intervention methodology is described in detail in the methodology section. Key assumptions in this study included:

1. H.U.B. City Steps participants were individuals 18 years of age or older and included both walking coaches and walking group members.
2. Implementation of the intervention was conducted by paid staff.
3. H.U.B. City Steps participants followed instructions that requested abstention from smoking, exercise, and caffeine intake for at least one hour prior to blood collection and measurement of blood pressure.
4. Participants were trained in how to appropriately use pedometers. Participants utilized pedometers as designed.
5. Each monthly Nutrition and Physical Activity Education Session Leader was trained and competent to teach the information provided; each session was delivered as planned.
6. Coaches were trained and certified in necessary skills to lead walking group members.
7. The H.U.B. City Steps participants gave accurate accounts of their food consumption.
8. The H.U.B. City Steps data collectors were well trained and followed established protocols for data collection including height and weight measures, walk test measures, dietary intake, and motivational interviewing.
9. All biochemical analyses were accurate and precise.
10. Motivational interviewing was conducted with high fidelity.
11. Study protocols and manuals of procedure were executed as written.

Limitations
1. The dietary data are self-reported data from study participants and are intended to be an indicator of usual diet related to the consumption of a limited number of foods/nutrients, and the change that occurs in those within the timeframe of this intervention, not a comprehensive dietary diary.
2. Diet quality is a computation using quartiles within our dataset to establish an overall measure of dietary quality for individuals within our sample and this additional computation within the dataset could possibly introduce error.
3. Physical activity data are self-reported from study participants and submitted as walking logs throughout the intervention.
4. Causal inference cannot be derived from analyses and can only be established through appropriate experimental design.

Strengths
Strengths of this study include the use of longitudinal data derived from a sample that was calculated based on power of 81% ($d= .81$). All measures used to gather data were previously validated for use in similar populations. All aspects of the intervention were theoretically based as mentioned in the conceptual framework and community sustainability was focused on through capacity building.

Conceptual Framework
Social cognitive theory and the transtheoretical model ([TTM], specifically processes of change), were theoretical models adopted by the intervention aspect of
H.U.B. City Steps while motivational interviewing was implemented as the approach to be used in intervention and maintenance phases to help facilitate participants’ progression through the stages of change.

These models/approaches were used to develop various aspects of the intervention including educational materials, participant counseling, and structure of social support and information dissemination. Multiple instruments/approaches were used to collect data related to the theoretical framework for the H.U.B. City Steps intervention and included psychosocial questionnaires, observations, focus groups, and motivational interviewer evaluations.

Social Cognitive Theory

The Social Cognitive Theory (SCT) has been used in many interventions with adults and adolescents in an effort to change dietary and/or PA behaviors. One of the reasons SCT is frequently used is because it has a number of constructs that can be applied at various points and it is very comprehensive (Baranowski, Perry, & Parcel, 2002). Furthermore, it is a theory that focuses on interpersonal roles and the impact of environment (social and otherwise). Social Cognitive Theory is commonly used in the design of nutrition education interventions (Contento et al., 1995) and proposes that one’s behavior is a function of the aspects of the environment as well as the person, all of which are in constant interaction. The primary premise is that people desire positive outcomes and will work to avoid negative consequences. Self-regulation and self-efficacy are concepts that are difficult to measure but are primary components of SCT (Bandura, 1997). Additionally, SCT research indicates that social support predicts increased PA either directly or indirectly through its impact on self-regulation and self-efficacy. Social
support has also been shown to be an indirect predictor of maintaining long-term PA and has been found to be an important psychosocial construct in behavioral intervention research in African American populations (Anderson, Winett, & Wojick, 2007). Since the main outcome of this study was to identify factors leading to improvement in the health indicator, the use of the SCT constructs were invaluable.

**Transtheoretical Model**

The transtheoretical model (TTM) has emerged as one of the foremost frameworks describing what occurs as individuals change their behavior. The framework, as described by Prochaska, Redding, and Evers (2002), suggests there are five stages which, when applied to PA, emerge as precontemplation (no intention to become physically active), contemplation (intention to become regularly physically active within the next six months), preparation (intention to become regularly physically active within the next 30 days), action (being regularly physically active 30 minutes per day, most days of the week, but only within the last six months), and maintenance (meeting physical activity recommendations for at least the past six months).

Another construct within the TTM framework is processes of change. There are 10 processes divided into two broader categories. The first category, named “experiential,” contains consciousness raising, dramatic relief, self-reevaluation, self-liberation, social liberation, and environmental reevaluation. The second category, “behavioral,” contains the processes of helping relationships, reinforcement management, interpersonal systems control, counterconditioning, and stimulus control. The experiential processes focus on thoughts, feelings, and experiences whereas behavioral processes focus more on behaviors and reinforcement (Prochaska, Redding, & Evers, 2002).
The TTM is intended to provide a framework to accelerate the rate of behavior change, for example, weight loss, in a specific population. It is important to first assess the stages or processes the individuals within the population are experiencing and then develop interventions that address those particular stages (Horwath, 1999). For example, an intervention would not be as effective if the activities were aimed toward participants in the action stage when these individuals were actually in the precontemplation stage. The effectiveness of behavior change interventions might be increased if the stages and processes are considered prior to intervention development (Herzog, Abrams, Emmons, Linnan, & Shadel, 1999). While the purpose of TTM is to provide a framework for behavior change, the purpose TTM served within this project was to differentiate between stages of change in participants and quantify the movement through stages of change in relation to health indicators throughout the intervention.

**Motivational Interviewing**

In addition to employing SCT and TTM, motivational interviewing (MI) was utilized. MI is a directive, participant-centered approach for evoking behavior change by assisting individuals in exploring and resolving ambivalence about change (Miller & Rollnick, 2002). MI has been studied extensively and is more recently being applied to behaviors outside the clinical setting (Resnicow et al., 2002). According to Hecht et al. (2005), MI shows promise as an efficacious intervention in a variety of settings and with a variety of health issues, including dietary and PA interventions.

Specific concern has been expressed that the core components, including the “spirit of MI,” be preserved even under varying conditions (Emmons & Rollnick, 2001). According to Miller and Rollnick (2002), the philosophy of MI is summarized by three
characteristics of the interventionist/participant relationship: collaborative, evocative, and honoring patient autonomy, which can, in turn, help participants to resolve ambivalence to change behaviors. Fortunately, a key characteristic of MI emphasizes that motivation is flexible and can be affected by the intervening relationships an interventionist has with the participant (Resnicow et al., 2002). The purpose of the MI within the context of this conceptual framework was to work in conjunction with TTM to move participants through stages of change by exploring readiness to change as well as addressing behaviors and barriers participants might be facing.

Statement of the Problem

Changes in PA and diet cannot occur in isolation; behaviors are embedded in a broader social network that includes community, society, and culture. Beyond the social influences on these behaviors are the personal characteristics and learned actions adopted through aging and development; modification of these PA and diet behaviors involve changing the way of living for many individuals. It is the factors that make this behavior change transition smooth that are of great importance PA and nutrition researchers, educators, and even policy makers. In order to advance scientific inquiry related to health behavior interventions, specifically PA and nutrition behaviors, identification of treatment specific factors, whether modifiable or non-modifiable, within a sample is imperative. If factors can be identified that will lead to meaningful and sustained behavior modification, interventions in general will be more beneficial to society as a whole.

In conclusion, nutrition and food related behaviors are multidimensional and complex; unfortunately, food related behavior is most often treated as a one-dimensional
or at best a few-dimensional variable. The purpose of this research was to uncover dynamic aspects of health and diet related variables in a complex environment without paring down data to a small number of linear associations.

Definition of Terms

*Coach Quality Score:* The coach quality score is comprised of two measures which include participation in total training hours (5-254 hours) and a Leadership Practice Inventory score (0-150 points). The hours were directly translated into points meaning that 20 hours of training was equal to 20 points. The two scores were summed to create a proxy reflecting coach quality based on time commitment and leadership ability (range=6-404).

*Community Capacity:* Community capacity has been defined as “the cultivation and use of transferable knowledge, skills, systems, and resources that affect community- and individual-level changes consistent with public health-related goals and objectives” (Goodman et al., 1998, p.258).

*Diet Quality Index:* A score indicating the degree to which an individual’s diet meets dietary recommendations for cardiovascular health which is calculated from the National Cancer Institute’s Multifactor Screener. A higher diet quality index has been indicative of a poorer quality diet and positively related to all-cause and all-circulatory-disease mortality rates in both women and men and to cancer mortality in men only (Seymour et al., 2003).

*Educational Sessions:* Monthly enrichment meetings (n=6) during the active intervention phase in which coaches and participants learned about nutrition and health. The education sessions focused on using key messages from Dietary Approaches to Stop
Hypertension (DASH). These messages include an eating plan that is rich in fruits, vegetables, whole grains and low fat dairy foods while maintaining a diet low in sodium, saturated fat and total fat (USDHHS, 2006)

*Exogenous Variables:* The exogenous variables are those in the model that have no causal links (arrows) leading to them from other variables in the model (Loehlin, 1992). In other words, exogenous variables have no explicit causes within the model.

*Growth Trajectory:* A growth trajectory, or developmental trajectory, describes the course of an outcome over time; it is the statistical model of longitudinal data exhibiting changes of a subject’s characteristics over time.

*Health Assessments:* Health screenings that coaches and participants received to assess variables tracked over the course of the intervention and maintenance periods. All assessments were free and took place before, during, and after the six-month intervention (at enrollment, 3, 6, and 18 months).

*Imputation:* The substitution of some value for a missing data point or a missing component of a data point.

*Improvement in Walking Behavior:* Variable used in a multiple regression analysis as an independent variable to predict a change in steps walked. Improvement in walking behavior was indicated by taking the mean of the steps walked in months 4 through 6 and subtracting the mean of the steps walked in months 1 through 3 \((\Delta_{\text{steps}}=X_{4\text{-}6}-X_{1\text{-}3})\).

*Incentives:* Tokens, rewards, or supplies given to add value in motivating H.U.B. City Steps participants to take part in intervention activities.
**Intervention Period:** The 6-month period when all participants were actively walking and receiving the same types of social and motivational support.

**Latent Constructs/Variables:** Variables that are unobserved or abstract; include variables such as health behaviors or psychosocial.

**Latent Growth Modeling:** A statistical technique used in the structural equation modeling framework to estimate growth trajectory; it is a longitudinal analysis technique to estimate growth over a period of time.

**Motivational Interview (MI):** Sessions with a motivational counselor who met with each walking coach and participant individually to help him or her carry out a personal walking plan. The first three sessions took place as part of the health assessments, and any others were by telephone.

**Participant:** Someone who completes the initial enrollment process for the H.U.B. City Steps intervention.

**Pedometers:** A piece of equipment worn by participants to measure and record steps and set daily walking goals.

**Psychosocial Construct:** A latent construct composed of the indicator variables Processes of Change, Self Efficacy, and Social Support.

**Socioeconomic Status (SES):** A description of a person’s societal status using factors or measurements such as income levels, marital status, educational achievement, neighborhood of residence, or home ownership.

**Walking Coach:** Hattiesburg community members who served as role models and group leaders during the intervention. Coaches recruited walking group members, provided direct links between walking group members and intervention staff, and
completed weekly activities to encourage participation of walking group members in H.U.B. City Steps.

*Walking Group:* Community members who united with the common purpose of establishing a health, fitness, and walking routine during the H.U.B. City Steps intervention; each group consisted of approximately 10-12 participants.

*Walking Log:* A log kept by each participant to record the number of steps taken each day during the intervention phase. The log was mailed to intervention staff using pre-paid postage or entered into an Internet website developed specifically for H.U.B. City Steps. Data on steps was collected from walking logs and entered in the H.U.B. City Steps database.
CHAPTER II

REVIEW OF RELATED LITERATURE

In order to develop more effective physical activity (PA) interventions it is important for interventions to be based on theoretical models that adequately explain and predict PA behavior (Baranowski, Anderson, & Carmack, 1998). Many theoretical models explain behavior and explain change mechanisms but the ability to predict PA behaviors based upon sample characteristics remains elusive. Furthermore, when the purpose of intervention based research is to change PA behavior, many published studies demonstrate little or no impact on sustained behavior change (Baranowski, Anderson, & Carmack, 1998; Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; King, Taylor, Haskell, & Debusk, 1988; Luepker et al., 1994). While it could be argued that the lack of proven sustainability is a function of the lack of longitudinal studies in this area, some projects have demonstrated limited, mildly sustained behavior change in specific, unique subgroups (King, 2001; Sallis, 2001; Young, Haskell, Taylor & Fortmann, 1996).

Additionally, there is evidence, brought by years of research that suggests regular PA has meaningful health benefits and is inversely related to diabetes risk and to cardiovascular and cancer morbidity and mortality (Meyerhardt et al., 2006; Warburton, Nicol, & Bredin, 2006). There are also behavior theories that target psychosocial constructs in an effort to evaluate and understand the mechanisms of behavior change. Essentially, there are known beneficial effects of PA in relation to improving positive health status but the exact relationships between theoretical variables and supposed related outcomes emerged as mediating variables instead of being directly predictive of health status (Baranowski et al., 1998; Laitakari, Vuori, & Oja, 1996). Baranowski and
colleagues (1998) and Laitakari and colleagues (1996) argued that interventions work by means of mediating variables and that current theoretical models do not sufficiently account for variability in targeted outcomes. Mediating variables are items that explain the relationship between the other variables in a model (Baron & Kenny, 1986). Baron and Kenny (1986) proposed that a mediating variable would account for the effect of an intervention and a resulting outcome if a positive relationship between the intervention and outcome were rendered non-significant after controlling for the mediator. Mediating variables highlight the importance of theory in understanding behavioral interventions since mediating mechanisms can be thought of as theoretical variables used to design and improve future interventions (Baranowski et al., 1997). If mediating variables can help disconfirm theoretical constructs, then the extent to which interventions can impact mediating variables places limits on the extent to which a theory based intervention can really impact behavior change. This being the case, interventionists should focus on measuring mediating variables more precisely and consistently so that when programs do have an effect, their success can be explained in literature and add to the behavior change theories that currently exist.

Unfortunately, most PA studies that have evaluated intervention-related psychosocial mediating variables have been inconclusive. Some support for social support and self-efficacy exists but finding significant effects of these constructs across studies has been inconsistent. Perhaps the lack of targeted or tailored interventions combined with low-powered analytical techniques could explain part of the inconsistencies as these factors impose significant limits on the conclusions regarding effectiveness of interventions to produce lasting behavior changes (Baranowski,
Anderson, & Carmack, 1998; Hansen & McNeal, 1996). Likewise, behavior can be
determined by environment, genetics, life events, and other experiences that a researcher
has little to no control over, and is a product of many variables that cannot be accounted
for in most behavioral theories (Dishman & Sallis, 1994). It is most likely that different
people change their behaviors for different reasons so a key to unlocking the secret of
sustainable behavior change would be to find what interventions work with which groups
of people and at what point these individuals are ready to modify health related
behaviors.

In order to best identify the points at which an individual is most ready to change,
an analysis can be performed that explains a single individual’s development path as well
as differences in these paths over time. Which variables exert important influence on the
rate of development and at what point the change is most drastic are important factors to
identify in future research.

Multivariate Analysis

A study by Roesch, Norman, Villodas, Sallis, and Patrick (2010) used a latent
growth curve analysis to examine intervention effects on PA behavior. The purpose was
to evaluate target mediators that increase or decrease the adoption of positive PA
behaviors; with this targeting of mediators, researchers could identify psychosocial
mediators that are most effective in adoption of these positive PA behaviors. Adults
enrolled in randomized controlled trials of health promotion and weight control
interventions were included in the analysis (n=842). The intervention, similar to the
intervention in the current project, was based on SCT as well as TTM. Measurements
were made at baseline, 6 months, and 12 months. The International Physical Activity
Questionnaire (IPAQ) was used to assess PA while a battery of surveys to assess psychosocial constructs included behavioral skills like decisional balance, self-efficacy and social support. After testing several meditational models, the researchers found that growth trajectories for decisional balance, self-efficacy, and social support were associated with higher activity at 12 months indicating that individuals employing greater behavioral skills were more active at 12 months.

Another study using multivariate analysis (Napolitano et al., 2008) was conducted to test theoretical constructs of processes of change, decisional balance, and self-efficacy in relationship to a PA intervention. This study used 239 participants who were mostly middle to high SES (annual income $50,000 [60.8%]), college educated (70.6%), white (90.3%) women (82.0%). Participants were randomly assigned to one of three intervention arms and data was collected at three time periods (0, 6, and 12 months). Using the suggested statistical methods proposed by Baron and Kenny (1986) and Judd, Kenny, and McClelland (2001), analyses were conducted in four steps. The results indicated that a complete mediation scenario was present with moderate indirect effects for both print and telephone interventions ($c=0.43, 95\% CI=0.12, 0.74$ and $c= 0.37, 95\% CI=0.07, 0.67$, print and telephone, respectively). The complete mediation scenario suggested that if the mediators (in this case, self-efficacy, processes of change, and decisional balance) are controlled for, the intervention no longer would affect the outcome. In summary, increases seen in physical activity were due to changes in behavioral processes ($a1=0.82, 95\% CI=0.54, 1.10$) and not to the type of intervention which the subject was assigned.
While univariate analyses by other researchers have suggested that behavior change theories like TTM and SCT along with respective constructs are modes to increase physical activity, a multivariate analysis in the study just described revealed a much more complex picture in which the interrelationships among theoretical constructs must be closely investigated. The authors recognized that the sample used might limit generalizability, but noted that deconstruction of theoretical components to determine which combination of components produced greatest behavior change in PA behavior would be beneficial in future analyses.

The techniques and methods used to perform LGM cannot, like any statistics used in correlational studies, establish causality or prove that any variable actually causes another variable. Readers should be cognizant of the fact that some mathematically viable models are not logical and may not be theory based; researchers must account for mathematical reason, sound theory, and logic before failing to disconfirm a particular model. SEM and LGM are very powerful statistical techniques that must be used with integrity and discretion.

A study by Chen, Srinivasan, and Berenson (2008) used data from the Bogalusa Heart Study to examine complex relationships of BMI and fasting insulin to other metabolic components. The researchers acknowledged the complexity of defining metabolic syndrome and the clustering of conditions associated with the phenomenon. The authors also stated that due to the complex associations only a multivariate analysis would effectively analyze the pathways. Structural equation modeling, specifically, path analysis was chosen as the most appropriate technique. The overall purpose of using these advanced statistical techniques in any nutrition or PA research is to acknowledge
that nutrition and food related behaviors are multidimensional and complex and then carefully seek to uncover dynamic aspects of variables in a multifaceted environment without paring down data to a limited number of linear associations.

Health Indicators

Health indicators are powerful tools for monitoring and communicating critical information about population health. They are useful in helping to identify priorities or target resources and for tracking progress towards goals, and can be used to define public health problems at a particular point in time, to indicate change over time in the level of the health of a population, to define differences in the health of populations, and to assess the extent to which the objectives of a program are being reached. Health indicators may include measurements of illness and disease or positive aspects of health like quality of life, life skills, or health expectancy.

The leading health indicators defined in Healthy People 2010 objectives include: physical activity, overweight and obesity, tobacco use, substance abuse, responsible sexual behavior, mental health, injury and violence, environmental quality, immunization, and access to health care (USDHHS, 2000). U. S. Department of Commerce, Economics and Statistical Administration, U.S. Census Bureau (2000) stated that indicators are the “object of routine data collection and analysis at the national, state, and local levels, with the potential availability of comparable data at community levels and for select population groups during the interval 2000 to 2010”(n.p.).

Biomarkers are characteristics that are objectively measured and usually used as an indicator of biological or pathogenic processes. They can be used alone, like blood pressure to diagnose hypertension, or in combination, like triglycerides, low density
lipoprotein and high density lipoprotein to diagnose dyslipidemia. Many biomarkers are easy to assess and are often part of routine examinations. Typically blood pressure, heart rate, and pulse are used as indicators of cardiovascular health while anthropometric measurements like weight, BMI, and waist circumference serve as indicators of obesity and body composition (Fogel, 2005; Shen et al., 2006). The current study included self-reported measures of hypertension, hypercholesterolemia, and hyperglycemia diagnoses so researchers could account for preexisting chronic conditions. Additionally, researchers used biological and anthropometric outcome data to test intervention effectiveness.

Literature linking PA to mortality risk ranges from the seminal work done by Morris and Heady in the 1950s reported in a review by Warburton, Nicol and Bredin (2006) to the more recent work published by Hu and colleagues (2004). Warburton and colleagues (2006) concluded that there is sufficient evidence that regular PA is associated with increased life expectancy; however, there are varying ideas about what amount of PA is actually regular. Furthermore, several research trials have exhibited that routine PA has been shown to improve lipid profiles, glucose utilization, and augment cardiac function as well as psychological well-being (Anderson, Schnor, Schroll, & Hein, 2000; Katzmarzyk, Church, Janssen, Ross, & Blair, 2005; Tuomilheto et al., 2001).

Waist Circumference

Historically, BMI has been used as a predictor of mortality and morbidity associated with several chronic diseases like CVD and diabetes. However, waist circumference (WC) has been determined to be a measure of abdominal obesity which in turn may predict obesity-related health risks (USDHHS, 1998). In fact, research by Zhu and colleagues (2002) indicated that WC may be a stronger marker of health risk than
BMI, but using the two in combination is the best predictor. Guidelines established by NIH specify that within each BMI category, individuals with increased WC are at higher health risk than individuals with more normal WC. Furthermore, central obesity is associated with increased triglycerides, high blood pressure, and abnormal glucose metabolism (Alexander, Landsman, Teutsch, & Haffner, 2003; Lakka et al., 2002).

Additionally, other tested anthropometric measures to assess obesity related health risk include hip or thigh circumference. These measures have been shown to be negatively associated with health risk (Seidell, Han, Feskens, & Lean, 1997) while WC is positively associated with health risk. Research by Janssen, Katzmarzyk, and Ross (2004) investigated whether BMI added to the power of WC in predicting health risk. Researchers used data from the third National Health and Nutrition Examination Survey (NHANES III) to develop a step-wise regression model in which various confounding and metabolic variables were included to examine independent and combined effects of WC and BMI on comorbidity. The researchers found that BMI along with WC does not predict an increase in health risk significantly better than WC alone. So, while BMI remains a significant predictor of metabolic health risk, WC is needed as a predictor of obesity related health risk and may in fact be a better marker of some health risks than BMI.

**Systolic Blood Pressure**

Hypertension screening is often an integral part of health promotion and disease prevention initiatives and individuals with hypertension often report inverse health-related quality of life (Fields et al., 2004). Typically more attention is given to systolic than to diastolic blood pressure as a major risk factor for cardiovascular disease for
people over 50 years old. In most people, systolic blood pressure rises steadily with age due to increasing stiffness of large arteries, long-term build-up of plaque, and increased incidence of cardiac and vascular disease (American Heart Association, 2002).

Research by Chan, Spangler, Valcour, and Tudor-Locke (2003) suggests that pedometer determined steps/day was inversely related to BMI, waist circumference and diastolic blood pressure. Furthermore, individuals with >9000 steps/day were most likely to have a normal weight. Even in youth, BMI and varying levels of PA may independently predict systolic blood pressure (SBP). A study by Gaya et al. (2009) reported that as sedentary activity increased so did SBP which was consistent with two other studies looking at cardiovascular risk factors (Sorof, 2002; Thompson et al., 2007).

**Body Mass Index**

Body Mass Index (BMI) is a ratio calculated from an individual’s height and weight (weight [kg] / height [m]²) and is regarded as a fairly reliable indicator of body fatness for most people. Despite the fact that BMI is not a direct measure of body fat, research has shown that BMI does correlate to more direct measures of body fat like hydrostatic weighing and dual energy x-ray absorptiometry (Mei et al., 2002; World Health Organization [WHO], 2003). BMI can be considered an alternative for direct measures of body fat as it is an inexpensive and fairly reliable method of screening for weight categories that may lead to health problems. BMI is not used as a diagnostic tool but rather as a screener to indicate that further assessments are warranted (Dobbelsteyn et al., 2001).

The correlation between BMI and body fatness is fairly strong but has been shown to vary by certain variables like sex, race, and age. For example, Gallagher et al.
(1996) found that women tend to have more body fat than men when BMIs are equivalent, and older people, on average, tend to have more body fat than younger adults when BMIs are equal. In a study by Ford, Moriarty, Zack, Mokdad, and Chapman (2001), data were reported that identified BMI as being a predictor of self-reported health-related quality of life. Consistent with Ford and colleagues’ (2001) findings, previous studies illustrated that the higher an individual’s BMI, the lower the individual rated a self-reported health-related quality of life (Han, Tijhuis, Lean, & Seidell, 1998; Lean, Han, & Seidell, 1999). It is also important to remember that BMI is only one factor related to risk for disease and thus in this study BMI is used as part of a larger health indicator latent variable. In order to assess likelihood of developing obesity-related diseases, other predictors are needed. Specifically, the National Heart, Lung, and Blood Institute (NHLBI) guidelines recommend looking at waist circumference and risk factors for diseases and conditions associated with obesity (for example, high blood pressure or physical inactivity). Overweight and obese individuals are at increased risk for many chronic diseases that may include conditions like hypertension, dyslipidemia, Type 2 diabetes, coronary heart disease, or stroke (USDHHS, 1998).

**Blood Glucose**

Blood glucose is an important indicator of health and can help to determine the proper functioning of hormones like insulin. A multicenter clinical research study, the Diabetes Prevention Program (DPP), found that participants who lost a modest amount of weight through dietary changes and increased physical activity sharply reduced their chances of developing diabetes during the study by losing 5 to 7% of their body weight (DPP Research Group, 2002). Subsequent analyses of DPP data have added to the
Evidence that changes in diet and physical activity leading to weight loss are especially effective in helping reduce risk factors associated with both diabetes and CVD (DPP Research Group, 2005; Hamman et al., 2006).

Several studies have indicated that improved control of blood glucose can be attained with a healthful diet (Chandalia et al., 2000; Pastors, Warshaw, Daly, Franz, & Kulkarni, 2002) and increased physical activity (Clark, 1997). A study by Lemon and colleagues (2004) showed that BMI, fasting plasma glucose, SBP and lipid profiles generally improved significantly between intervention baseline and three months, while stabilizing between three and six months. This research shows that different trajectories can be seen over time periods which not only makes the case for using multivariate statistical methods in research designs such as this but also argues that blood glucose control plays an integral part in optimizing health indicator outcomes.

Socioeconomic Status, Physical Activity, and African Americans

It has been known for more than a decade that physical inactivity rates are highest among women, minorities, and lower socioeconomic groups (USDHHS, 2008). African Americans are disproportionately affected by heart disease; however, overall risk can be reduced through lifestyle changes, including exercising regularly, losing weight or maintaining a healthy weight, and controlling diabetes. A systematic review published in 2009 (Whitt-Glover & Kumanyika) included articles from 1985-2006 that reported data about fitness changes in African Americans. Fewer than 50 (n=43) articles were identified as being relevant. Studies were then ranked for study quality based on the following characteristics: degree of focus on PA, inclusion of PA goals in the intervention, PA assessment method, and cultural adaptation. The authors reported that
among all studies there was a modest short and long term success for improving levels of PA in African Americans. The highest ranking studies among all age groups were those that had a randomized control trial design and specific goals such as targeting PA. Those with high quality scores also showed within and between group effects when comparing PA levels of intervention and controls from baseline to completion. The authors stated that because so few long term data are available, there is no way to draw conclusions on the long term effects of these interventions. There were many approaches to increasing physical activity, and the most common approach focused primarily on increasing PA and setting goals; the second most common approach was to include weight loss with PA.

Psychosocial Constructs

The Institute of Medicine ([IOM], 2001) report on health and behavior recommended that collaboration among multiple disciplines become more frequent. The report stated that in order to understand and influence health behaviors, the recognition that health and disease are determined by interactions of biology, psychology, and behavioral factors must be present (IOM, 2001). An article by Baron and Kenny (1986) made very clear the need for moderator-mediator distinctions in social research but in 2002 a review article was published that found only 12 behavioral studies employing mediation analysis to test effects of theoretical constructs (Lewis, Marcus, Pate & Dunn, 2002). Additionally, a commentary by Baranowski, Cullen, Nicklas, Thompson, and Baranowski (2003) raised the question, “Are current health behavior change models helpful in guiding prevention of weight gain efforts?” (p. 23S). These authors not only looked at weight gain prevention and nutrition, but also PA. The conclusion was that until there is a better understanding of behavior and the way that interventions work in
conjunction with theory, more effective programs will not be designed. The H.U.B. City Steps intervention is based on two psychological constructs, Social Cognitive Theory (SCT) and the Transtheoretical Model (TTM).

Social Cognitive Theory

It is commonly known that in order for interventions to be highly effective, they should be based on sound theoretical models that can explain and predict behavior or behavior changes. Social Cognitive Theory is a widely used theoretical approach in PA interventions; however, the actual process by which SCT influences behavior change has not been clearly elucidated (Anderson, Winnett, Wojcik, 2007; Anderson, Wojcik, Winett & Williams, 2006). Some of the key constructs within SCT and relating to PA are social/environmental supports, self-efficacy, outcome expectations, and self-regulation. A study by Rovniak et al. (2002) investigated a SCT model of PA by exploring the direct, indirect, and total effects of SCT constructs. Researchers also developed and tested measures of exercise self-regulation and PA. The prospective design included a final sample of 283 undergraduate students. Latent variable structural equation modeling (SEM) was used to test the fit of the proposed SCT model with the data collected. Maximum likelihood estimation was used and the goodness of fit index (GFI) as well as the adjusted GFI (AGFI) was expected to be >.90 while the root mean square of approximation (RMSEA) had to be not significantly greater than 0.05. An ANOVA was conducted to test whether the sample at follow-up was significantly different than the original sample; there were no significant differences in any measured variables between baseline and follow-up.
Researchers reported initial testing of the measurement model indicated a modest fit to the data where \( \chi^2 = (35, N=277) = 131.89, p<.001, \text{GFI}=.92, \text{AGFI}=.85, \text{RMSEA}=.10. \) Fit was improved by allowing errors associated with outcome expectations subscales to correlate and measures of energy expenditure and PA models to correlate. The fit improved and was considered good at \( \chi^2 = (33, N=277) = 58.60, p=.41, \text{GFI}=.96, \text{AGFI}=.93, \text{RMSEA}=.05. \) The model explained 55% of the variance in PA at the 8-week follow-up.

Next, the effects of each construct on PA were described. Higher levels of social support led to higher levels of self-efficacy; self-efficacy had the greatest total effect on PA (\( \beta_{\text{total}}=.21, \text{ns}, p<.001 \)) and was mostly mediated by self regulation (\( \beta_{\text{indirect}}=.57, p<.05 \)). Self-regulation directly resulted in higher levels of PA; however, outcome expectations did not have significant effects on PA. These findings suggest that self-regulation and self-efficacy are important constructs to incorporate when forming an intervention and perhaps if these constructs are developed in participants, favorable changes in PA behaviors will be seen. Additionally, this research is valuable in that it is one of very few studies that use prospective data in an SEM model. Despite the limitations inherent in this study, the researchers provided a robust framework in which SCT was empirically evaluated using a continuum of constructs and not simply choosing one construct to further develop.

Social support. Self-efficacy and social support are positively associated with PA level, although few studies have evaluated these associations among minority women. Social support has been identified as a key determinant of PA participation, has been shown to be an indirect predictor of maintaining long-term physical activity, and has been found to be an important psychosocial construct in behavioral intervention research in
African American populations (Harley et al., 2009; Peterson, Yates, & Hertzog, 2008; Spanier & Allison, 2001). Social support has been defined broadly as resources provided by other persons (Cohen & Syme, 1985) and specifically as “the individual belief that one is cared for and loved, esteemed and valued, and belongs to a network of communication and mutual obligations” (Cobb, 1976, p.301). Social support can include familial, spousal, and friend support. While social relationships and health have been studied cross-sectionally since the early 1970s, and many longitudinal studies have been conducted that demonstrate that a lack of social support is a risk factor for mortality, there are still questions to be answered about its relationship to specific health issues (Harley et al., 2009; Peterson, Yates, & Hertzog, 2008; Spanier & Allison, 2001; Thomas et al., 2009). Some studies focus on the benefits of receiving social support and that receiving social support results in lower blood pressure (Dressler, 1991; Eyler et al., 1999; Spanier & Allison, 2001).

In 1987, Sallis et al. attempted to develop measures of perceived social support specific to health-related eating and exercise behaviors. The researchers identified meaningful factors and developed scales that represented social support constructs between family and friends. These factors were developed into social support scales which were tested for validity and then modified to specifically correlate with self-reported dietary and exercise habits. In constructing these scales, Sallis and colleagues produced seminal work that described objective measures to evaluate social support in the context of health behaviors. Following this development were many researchers that included the social support variable into behaviors ranging from smoking cessation to various levels of physical activity behaviors and diet.
For example, a study of physical activity social support (PASS) was conducted by Eyler et al. (1999) and identified determinants of PA in a racially diverse sample of women. The researchers used a modified-random cluster sampling technique on secondary data from the U.S. Women’s Determinants Study. Physical activity social support questions were part of the national survey about risk factors among women and consisted of five questions with four answer choices ranging from “strongly agree” to “strongly disagree.” Cut-points were developed for participants to be classified as “sedentary” (no participation in exercise or physically active hobbies in the past two weeks), “regular exercise” (participation in leisure-time PA at least five days for 30 minutes), “cumulative exercise” (accumulating 150 minutes of PA per week), and “lifestyle activity” (total PA calculated from leisure, housework, and occupation). Separate logistic regressions were run using PASS scores as the independent variable and the four categories as dependent variables. Potential confounders included race, marital status, age, education, and income and were included in the final model only if the original odds ratio changed by 10% or more.

The sample included 2,912 racially diverse women. American Indian women had the highest frequency of sedentary behavior and the second highest frequency of lifestyle activity. African American women were second only to American Indian women with frequency of sedentary behavior and lowest for frequency of regular exercise. Hispanic women had the largest frequencies for regular exercise, cumulative exercise, and lifestyle activity.

Chi square indicated a significant difference among racial groups for the total PASS score where Hispanic women had the largest percentage in the “high” PASS score
as well as in the Family PASS and Friend PASS score. This study indicated that those with higher PA social support were less likely to be sedentary when confounders were controlled. There was no difference among participation in intervention exercise in the three activity categories, but there was a difference in the sedentary category suggesting that the largest barrier is to go from sedentary to active but once an individual is active they are more likely to continue the habit of exercising.

Another example of social support research is a study by Anderson, Winnett, and Wojcik (2007) in which all the constructs of SCT were evaluated using structural equation modeling (SEM). Participants included 1,194 adult members of church denominations; the sample was predominantly overweight or obese (79%) and Caucasian females (66%). The researchers attempted to model the extent that constructs of SCT (self-efficacy, social support, outcome expectations, and self-regulation) influenced nutrition behaviors. The fit of the models was good (RMSEA <.05) and it was shown that family social support made an important impact on healthier nutrition. The authors found that the total effect of the social support variable was in part indirectly through self-efficacy and self-regulation; therefore, the authors concluded that self-efficacy and self-regulation must be included along with social support building to make nutrition interventions the most effective. Even though the data was collected through a non-experimental design, the importance of social support on healthy behaviors is evident from the modeling done by these researchers. The findings are suggestive of the fact that future interventions may benefit by strengthening family support, building self-efficacy, and appropriately targeting certain demographic groups.
Self-efficacy. Self-efficacy beliefs determine how people feel, think, motivate themselves and behave so that a strong sense of efficacy may enhance personal well-being (Bandura, 1997). Bandura proposed that the self-efficacy construct may be one of the most important prerequisites for behavior change and is seen as a primary predictor of intention to engage in healthier behaviors (Bandura 1977, 1978). A specific practice to increase self-efficacy is the idea that through repeated successful attempts at incremental tasks, one comes to have expectations of success and therefore will continue to build on the small task until change is produced (Bandura, 1997). Furthermore, the issue with self-efficacy and health, specifically PA, has become that an individual’s confidence in ability to perform certain physical activities for a specified amount of time on a daily basis must supersede the overarching and often immeasurable goal of performing PA regularly. For example, the recommendation that 150 minutes per week of PA is required for health may imply that if an individual is not able to attain this goal s/he may cease trying. However, if small incremental bouts of exercise can be completed this may increase self-efficacy until the behavior becomes normative.

As mentioned above, the study by Anderson, Winnett, and Wojcik (2007) used SEM to explore relationships between SCT constructs and nutrition behaviors; self-efficacy was considered in the context of an SEM. The researchers suggested that this modeling procedure revealed the need for nutrition interventions to target goals and skills like planning and monitoring progress to achieve goals. Participants with higher confidence in abilities to make healthy choices had lower levels of fat and higher levels of fiber. The finding that the effect of self-efficacy on nutrition occurs indirectly through
other SCT constructs, like social support, is similar to findings in exercise and PA literature.

Duncan and McAuley (1993) used latent growth modeling techniques to explore the relationship between PA and social support and reported that self-efficacy was a mediator between the two. Likewise, self-efficacy has been shown to be a significant predictor in the duration of PA (Sharma, Seargenat, & Stacy, 2005) and a study by Orsega-Smith, Payne, Mowen, Ho, and Godbey (2007) found that adults that met CDC recommendations for PA reported statistically significantly higher levels of self-efficacy and social support.

Finally, a review by Sherwood and Jeffery (2000) reported that of all the psychological constructs related to PA behavior, exercise self-efficacy may be one of the most consistent predictors of PA behavior because it predicts both intention and behavior. Several authors have suggested that self-efficacy should be an outcome by itself (McAuley, Lox, & Duncan, 1993; Oka, King & Young, 1995). This notion of enhancing self-efficacy to achieve PA goals has slowly been weaved into PA recommendations. Some of the literature coming from the late 1980s and early 1990s suggested that short, acute bouts of PA and self-monitoring may increase self-efficacy. Currently, the CDC is promoting the practice of short bouts of PA as long as the activity is done at a moderate or vigorous effort for at least 10 minutes (CDC, 2005b). This integration of behavioral research and PA policy is a great example of how evidence based practices can be disseminated to the public.
Transtheoretical Model

The Transtheoretical Model (TTM) has emerged as one of the foremost frameworks describing how to understand what occurs as individuals change their behavior. The framework suggests there are five stages when applied to PA. These constructs are precontemplation (no intention to become physically active), contemplation (intention to become regularly physically active within the next six months), preparation (intention to become regularly physically active within the next 30 days), action (being regularly physically active 30 minutes per day, most days of the week, but only within the last six months), and maintenance (meeting physical activity regularity requirements for at least the past six months).

Processes of change. In addition to the stages of change is a construct within the framework called the processes of change. There are ten processes divided into two broader categories. The first category, named experiential, contains consciousness raising, dramatic relief, self-reevaluation, self-liberation, social liberation, and environmental reevaluation. The second category, behavioral, contains the processes of helping relationships, reinforcement management, interpersonal systems control, counterconditioning, and stimulus control. The experiential processes focus on thoughts, feelings, and experiences whereas behavioral processes focus more on behaviors and reinforcement.

The TTM is intended to provide a framework to accelerate the rate of behavior change in a specific population. It is important to first assess the stage or process the individuals within the population are experiencing and then develop interventions that address those particular stages. For example, an intervention would not be as effective if
the activities were aimed toward participants in the action stage when these individuals were actually in the precontemplation stage. The effectiveness of behavior change interventions might be increased if the stages and processes are considered prior to intervention development.

The Transtheoretical Model has been extensively used to build effective behavior change interventions in many aspects of behavior, and specifically physical activity. Many populations have been targeted for research and include those with low, moderate, and high socioeconomic status, those with various chronic diseases and distinct age groups. Fairly recent research as reported by Kloek, van Lenthe, van Nierop, Schrijvers, and Mackenbach (2006) examined the stages of change for a group of lower socioeconomic participants participating in moderate intensity physical activity. The data used in this report were from a baseline cross-sectional study of a community intervention intended to improve health related behaviors. The sample included 2,574 adult participants from the Netherlands. Physical activity, stage of change, self-efficacy, social support, health related behaviors, diet, knowledge of PA recommendations, and socio-demographic factors were taken into account.

The researchers found that almost half (49%) were in the maintenance phase while 15% were in action, and 36% were in a pre-action stage. Regardless of stage, most (57%) respondents did not meet the requirements for moderate intensity PA requirements. Furthermore, age, education, health related behaviors, and knowledge were all associated with the reported stage of change. The authors concluded that despite the fact that their research was specific to low socioeconomic populations, it also highlighted the need to improve PA behavior by making people aware that they do not behave
according to recommendations for PA. Furthermore, interventions developed for similar populations can be tailored to the psychosocial and external factors that were found to be significant.

Another research study using a specific population in relation to a particular TTM construct was conducted through the Well-Integrated Screening and Evaluation for Women Across the Nation (WISEWOMAN) study. Rye, Rye, Coffindaffer, and Tessaro (2009) reported on a subset of data in order to identify potential perceived barriers to PA in relation to the stage of change and BMI for a sample of women. Participants had weight, height, demographic questions, perceived barriers to PA, and stage of readiness to change PA assessed. For each barrier a chi square test was used to ascertain statistically significant differences, and from this point a Mann-Whitney test (sig=.005) was used as post-hoc test if the results were significant. However, the Bonferroni correction was used with BMI and therefore permitted a higher significance level (.017).

The sample included 733 women who were all low income and predominantly white (93.9%) and overweight (84% overweight or obese). The most frequently reported barrier to PA was lack of support (52.4%) followed by lack of willpower, money, time, and place (50.8%, 35.2%, 30.1%, and 19.2%, respectively). A little over half (51.8%) of the women were classified as being in the maintenance stage. One-way ANOVA revealed no significant difference in barriers between the stages of change across any stages of change. As for barriers by BMI, the most frequently reported barrier for normal weight women was lack of support (49.1%) while the obese group reported lack of willpower and lack of support (54.5% and 52.6%, respectively) most frequently. While the authors stated they suspect the action and maintenance phases were over-predicted in this sample,
they still concluded that barriers consisting of lack of willpower and lack of support are common themes that should be addressed in future research.

A recent study by Kirk, MacMillan, and Webster (2010) looked at the application of the TTM to PA in older adults with chronic diseases like Type 2 diabetes (T2DM) and cardiovascular disease (CVD). The sample included 85 people with one (T2DM=35, CVD=28) or both (n=22) of these chronic diseases. Multiple, validated questionnaires were given to assess the constructs of behavior change and measure the stage of exercise behavior change, and included self-efficacy, decisional balance, and processes of change along with a seven day physical activity recall questionnaire.

The researchers used ANOVA to test for differences across the stages for each construct. Results revealed that total reported PA increased from contemplation to action and decreased from action to maintenance. The only significant differences were from contemplation to maintenance (p=0.02) and in self-liberation. This research, despite several limitations, looked at specific populations of individuals with chronic disease and although not significant, indicates that as people progress to higher stages of change, higher levels of PA, self-efficacy, and pros on decisional balance are reported. This research could be useful in designing stage matched interventions for special populations; however, the concern over using TTM in general is expressed in other literature. In particular, the continuity of the stages is questioned as some researchers propose that a true stage model would have distinct periods of change (Sutton, 2005).

Motivational Interviewing

According to Miller and Rollnick (2002), motivational interviewing (MI) is a directive, participant-centered approach for evoking behavior change by assisting
individuals in exploring and resolving ambivalence about change. Motivational interviewing has been studied extensively and is more recently being applied to behaviors outside the clinical setting (Resnicow et al., 2002). According to Hecht et al. (2005), MI shows promise as an efficacious intervention in a variety of settings and with a variety of health issues, including dietary and physical activity interventions.

A meta-analysis by Burke, Arkowitz, and Menchola (2003) looked at 30 controlled clinical trials to examine MI effectiveness. While most of the articles included in the analysis were focused on substance abuse or smoking cessation, some were about diet and exercise. These researchers determined that MI interventions were just as effective as other treatments and were more effective than no treatment. A 2004 analysis by Burke, Dunn, Atkins, and Phelps looked at 39 studies utilizing MI and found similar results to the 2003 study described previously. A more recent addition to the MI body of research is a summary of studies provided by VanDorsten in 2007, which stated that in the eight studies on weight loss and two on exercise, MI was shown to significantly improve diet and exercise behaviors as well as adherence and weight loss. In conclusion, MI seems to be supportive of behavior change in relation to diet and physical activity as researchers have reported participants’ increased self-efficacy (Bennett, Young, Nail, Winters-Stone, & Hanson, 2008; Resnicow et al., 2004), increased PA (Bennett, Lyons, Winters-Stone, Nail, & Scherer, 2007; Carels et al., 2007; Hardcastle, Taylor, Bailey, & Castle, 2008), increased fruit and vegetable consumption (Hardcastle et al., 2008; Resnicow et al., 2000, 2004) and decreased BMI (Hardcastle et al., 2008; Schwartz et al., 2007) after interventions containing MI components.
Self-Rated Health Status

In 1993, the Centers for Disease Control (CDC) supported the addition of four health-related quality of life questions to the Behavioral Risk Factor Surveillance Survey (BRFSS). The primary question asked, “Would you say that in general your health is excellent, very good, good, fair, or poor?” The question was intended to help track physical and mental health trends in the population. This question, in particular, has been found to accurately predict mortality and has served as an indicator measure for chronic health conditions (Burstrom & Fredlund, 2001; Idler & Benyamini, 1997). Many community surveys have used self-rated health as a common metric to assess perceived health risk. The validity of this single-item subjective measure of overall health has been shown rather extensively in population studies (Burstrom & Fredlund, 2001; Heidrich, Liese, Lowel, & Keil, 2002; Lyyra, Heikkinen, Lyrra, & Juylha, 2005) and remains a sensitive measure to evaluate health status.

While it is clear that self-reported health ratings are discounted if other, more objective health status indicators are present, these self-reports may indeed be reliable predictors of health-related events. A study dating back to 1971 indicated that self-rated health is second only to age in its power to predict morbidity and mortality (Mossey & Shapiro, 1982). Self perceptions of health status may be influenced by social support. Further, social support and social integration are thought to have effects on immune response and cardiovascular systems as well as health related behaviors, which may in turn affect self perception of health (Michael, Berkman, Colditz, Holmes, & Kawachi, 2002; Seeman, 2000). Relationships among social support, perceived health status, and
physiological indicators are of interest in the context of the research carried out for the researcher’s dissertation.

Coach Quality and Leadership

Leadership is often thought of as the means by which people are influenced to achieve goals (Northouse, 2007). Leadership has been studied in the business and managerial disciplines for years; however, its introduction to behavioral and social science disciplines has been slower. The Leadership Practices Inventory (LPI) contains 30 statements; six statements measuring five different constructs that represent practices of “exemplary leaders.” Each statement has a five-point Likert scale where a higher value represents more frequent use of positive leadership behavior (total score range: 30-150). Reliability measures for the LPI constructs are consistently between .75 and .87. The five factors were extracted with eigenvalues greater than 1.0 (Carless, 2001).

The LPI was originally developed in 1983, by Kouzes and Posner in an effort to measure transformational leadership and original instruments were more qualitative in nature to allow for survey development (Carless, 2001; Kouzes & Posner, 1988). The LPI has been widely tested and used throughout the world in managerial situations to assess leadership style and provide feedback to organizations (Kouzes, Posner, & Biech, 2010).

LPI validation research found that leaders with higher scores on their LPI are viewed as better leaders and have higher performing teams because the individual is using effective leadership behaviors more frequently. Leadership behaviors include Modeling the Way, Inspiring a Shared Vision, Challenging the Process, Enabling Others to Act, and Encouraging the Heart. This particular leadership instrument was selected for the present study because leadership behaviors are very specifically defined, the
behaviors characterize leadership constructs previously reported in literature so comparisons between fields can be made, and transformational leadership qualities are clearly stated. While the LPI is a sound instrument that has been used across a wide variety of settings, leadership behaviors are self-reported and that may introduce bias.

The role of the H.U.B. City Steps Walking Coach, as stated in the Walking Coach Manual of Procedures, is “fundamental to the success of H.U.B. City Steps since the coach resides in the community and has the ability to provide long-term modeling to promote health and fitness” (p. 6). Walking Coaches were tasked with role modeling healthy behaviors, involving community members and encouraging group members to be active in the intervention. Coaches were required to attend all education sessions and health assessments as well as keep weekly time sheets that recorded phone calls and contacts with walking group members. The contact and role modeling expected from these individuals was representative of the ideals of leadership measured by the LPI.

Dietary Intake

The impact of nutrition on health is quite substantial as evidenced by the volumes of literature produced each year regarding nutrition interventions and health related outcomes. Specifically, diet related chronic diseases disproportionately affect African Americans and those with low incomes. The dietary variables included in the model proposed in this study are not intended to quantify dietary intake but rather to quantify change in intake over the intervention period. The major aspects of the Dietary Approaches to Stop Hypertension (DASH) diet was the focus of the nutrition education component of the intervention. Increases in fruits and vegetables as well as fiber have been shown to lower cholesterol, blood pressure, and BMI (Carter, Gray, Troughton,
Khunti, & Davies, 2010; Liu et al., 2000; Van’t, Jansen, Klerk, & Kok, 2000).

Additionally, the DASH diet’s focus on lower sodium foods and a reduction in saturated fat has been shown to be effective in optimizing health outcomes (Cohen, Hailpern, & Alderman, 2008; Schneider, Messerli, Garavaglia, & Nunez, 1988; Strazzullo, D’Elia, Kandala, & Cappuccio, 2009).

Despite the importance of dietary intake and respective impacts on health, measuring dietary intake accurately is a very tedious process. While there is no gold standard method of assessment, research has sought to validate current instruments like the 24-hour dietary recall, three day food record, and food frequency questionnaire (FFQ). With 24-hour recalls the dietary intake can be quantified and food intake is detailed enough to suggest specific nutrient intakes, cooking practices, and eating patterns (Thompson & Subar, 2001). However, these recalls rely on self-report which may introduce error from participants forgetting foods and underreporting consumption (Krall, Dwyer, & Coleman, 1988). Recalls are costly to administer and several studies indicate that multiple days of intake are required to estimate usual intakes (Beaton, Milner, McGuire, Feather, & Little, 1983; Thompson et al., 2004). A food diary or three day food record also may provide quantified, detailed information but there is a high respondent burden and again, underreporting consumption is common (Yanek, Moy, Raquenorn, & Becker, 2000). The third popular type of diet assessment technique is an FFQ. Like the other methods, this too has weaknesses that include lack of detail, cognitive complexity, measurement error, and a finite food list. Some of the strengths of an FFQ, however, include the very low response burden, ability to estimate usual intake
in one administration, and low cost of administration (Abramson, Slome, & Kosovsky, 1963; Goldbohm et al., 1995).

It is imperative to carefully choose the tool best suited for the research questions being asked in order to accurately assess dietary intake. Many characteristics of the sample must be considered since gender, age, education and reading level, income level, and culture or ethnicity all play into the reliability of self-reported data that is obtained by dietary intake tools. After assessing the characteristics of the target population, researchers with the H.U.B. City Steps study chose to employ the National Cancer Institute (NCI) Fruit and Vegetable Screener ([FVS], NIH, 2005), a food frequency type instrument. The chosen FVS allows proper evaluation of the emphasis placed on the DASH diet within the nutrition education component of the intervention. It should be noted that even though the FVS provides a rough estimate of usual intake of fruits and vegetables, it is not as accurate as more detailed methods described above. While the objective of the H.U.B. City Steps intervention was not to assess total diet intake, but rather changes in intake over the course of the intervention, the FVS screener was quite suitable for use. Furthermore, this FVS was chosen because within the anticipated time limits of the other outcome variables being assessed, it is brief and easily administered. Validation research with the FVS indicates that estimates may be useful to discriminate among individuals with regard to higher vs. lower intakes, and to allow examination of interrelationships between diet and other variables (Subar et al., 2001).

Greene et al. (2008) evaluated this FVS in ethnically diverse populations. The authors assessed the correlation of the FVS, multiple 24-hour recalls, and serum carotenoid (SC) levels of participants at four different sites that were members of the
Behavior Change Consortium (BCC). Not only did the authors assess the correlations, but also the difference of intake estimations between the three different methods. The sample (n=590) was limited in diversity as it included participants that were primarily female (72%) and only 3.5% were African American. Statistically significant correlations between FVS and the 24-hour recalls were found in most sites. The FVS overestimated intake by 1.76 servings in men and 2.11 servings in women when compared to the 24-hour recall. The question remained whether the overestimation was due to reports by participants or if the screener was at fault because of inaccurate estimation equations.

Another report based on BCC participants was published by Peterson and colleagues (2008), who reported evaluation of the performance of the 19-item FVS in comparison to a single fruit and vegetable intake question on ability to measure change in fruit and vegetable intake. Researchers also examined the cross-sectional capacity of these two measures in evaluating fruit and vegetable intake compared to three 24-hour recalls. The researchers analyzed data from 315 BCC participants who for this sample tended to be older than 60 years of age (n=82) and female (n=222), while only 31% were African American (n=97). Researchers found that the FVS significantly over-reported fruit and vegetable intake when compared to at least one 24-hour recall while the one item measure significantly underestimated consumption relative to the 24-hour recall. Further, when using a measurement model procedure where the 24-hour recall was baseline, cross-sectional deattenuated correlations of the FVS and the 1-item measure with the 24-hour recall were non-significant. As for measures of change, no significant treatment effects were found with any of the instruments over two years following a randomized control behavior intervention design (Yaroch et al., 2008).
The analytic approaches used in this study were focused specifically on measuring fruit and vegetable intake with short and long screeners. The researchers suggested that one explanation for the overestimation in the 19-item FVS could be that larger numbers of response items may contribute to overestimation. The capacity to measure changes when using screeners is questionable from these results. The screener findings were consistent with serum carotenoid measures that also revealed no changes. The authors suggested that continued testing with longitudinal data is essential to understand the limitations and benefits of using FVS as evaluation tools.

Walking and Pedometers

Walking is thought to be one of the most popular leisure time activities and can be a safe, inexpensive form of exercise that is available to most individuals. Walking has been referred to as a near perfect exercise and can be incorporated into everyday life as well as sustained into old age (Siegel, Brackbill, & Heath, 1995).

Total daily physical activity is considered a sum of all occupational, household, and leisure time activity. Traditionally, PA has been assessed using self-report methods which are known for inaccuracies and measurement bias. More recently, pedometers have been made available that are inexpensive and simple to use (Bravata et al., 2007; Tudor-Locke et al., 2005). Pedometers are small devices that sense body motion and then count footsteps; the count is converted into distance by knowing the length of the individual’s usual stride. Some evidence suggests that wearing a pedometer and recording daily steps and distance is a motivating tool (Tudor-Locke, Williams, Reis, & Pluto, 2002; Tudor-Locke et al., 2005). The immediate feedback and self-monitoring that pedometers provide, used in conjunction with goal setting, are significant contributions to
initiation and maintenance of PA. Previous validation studies indicate that pedometer
determined activity (steps/day) is inversely associated with percentage body fat and BMI,
and it is also related to ventilatory threshold, index of fitness, and heart rate kinetics
(Schneider, Crouter, & Bassett, 2004). Unfortunately, the efficacy of pedometer based
interventions remains unclear partially due to small scale trials. Studies with clinical
populations seem more definitive; however, these trials often involve participants with
diagnosed chronic disease states and incorporate physician based care as well as

A cross-sectional study was conducted by Chan, Spangler, Valcour, and Tudor-
Locke (2003) in which researchers described the relationship of pedometer steps and
general indicators of health as well as the diagnosis of one or more components of
metabolic syndrome. The researchers targeted sedentary worksites where a principal
contact was established and the contact was then responsible for recruitment. Each
participant (n=174) completed a questionnaire with demographic information and
occupational activities as well as having height, weight, waist circumference, and blood
pressure at rest measured. Pedometers were given to participants to wear for two working
days and one non-working day. Descriptive data reported showed that the sample
included mostly females (86.8%) employed full time (91.2%) at a moderately or highly
sedentary job (76.2%). Not surprisingly, 77.7% of the participants were overweight or
obese and the mean waist circumference for both men and women was greater than the
criterion for health risk.

Spearman’s correlations were used for non-normally distributed data and
categorical analyses used chi-square tests, Student’s T-test, and ANOVA. Self-reported
measures of PA had no relationship to any health indicators in this study but pedometer steps/day were significantly inversely correlated with BMI ($r=-0.04005$, $p=<0.0001$) as well as female waist circumference ($r=-0.4303$, $p<0.0001$). A low inverse correlation was found between diastolic blood pressure and steps/day ($r=-0.2140$, $p= 0.0383$) and a nearly significant relationship between systolic blood pressure and steps ($r=-0.1913$, $p= 0.0648$). Additionally, participants who reported having at least one factor other than obesity related to metabolic syndrome took fewer steps/day ($6311 +/- 3051$, $n=43$) than those not reporting associated conditions ($7655 +/-3479$, $n=136$). This sample fell at the lower spectrum of recommended steps/day and helps reiterate the idea that individuals who achieve >9000 steps/day are more likely to be of a normal weight.

A study by Zoellner and colleagues (2010) reported results from a community based participatory research walking intervention aimed at increasing PA and decreasing blood pressure in African Americans. The study included a total of 66 participants who completed the entire six-month trial. A trend was noted for participants classified as sedentary or inactive to have improved body fat levels post-intervention compared with those in other activity categories. Additionally, as triglycerides decreased the steps/day tended to increase. The authors stated that the continuous monitoring of PA was a particular strength of the study despite the fact that PA intensity was not measured.

The recommendation for adults to engage in moderate intensity PA for a minimum of 150 minutes each week was established in the USDHHS 2008 Physical Activity Guidelines for Americans. In contrast, a common recommendation of PA interventions and physical activity campaigns is to accumulate 10,000 steps per day (Craig, Tudor-Locke, & Bauman, 2006; Hatano, 1993; Wyatt et al., 2004) but does not
include a specification for type of activity or rate/intensity. A beneficial step in PA research would be to translate national PA recommendations into steps/day for moderate-intensity walking.

Some evidence suggests that approximately 30 minutes of moderate-intensity walking translates to about 3000-4000 steps in healthy adults. In 2009, Marshall et al. evaluated the use of a commercially available pedometer and determined the range of steps/minute at moderate-intensity for people of differing weight status in order to translate PA recommendations into a pedometer-based step goal. While the sample consisted only of 97 Latino adults (39 men, 58 women), the study was otherwise well designed. Two pedometers were placed at each participant’s waistband and all pedometers were checked for accuracy using the 20-step test. Participants then performed up to four 6-minute incremental walking bouts on a treadmill. Expired air, heart rate, and perceived exertion were measured. Separate 2x4 ANOVAs were conducted for each hip placement site to examine differences in step counts obtained from pedometers as well as from hand tallies of steps. No significant main effects were found so the left-hip placement was used for all further analyses. Multiple regression was used and explained 35% of variability in step counts obtained from pedometers as compared to steps counted by hand ($R^2=0.35$, standard error of estimate [SEE] =1.30, $p<0.001$). Considerable error is present using pedometer step counts and this research found that 15%-41% of variance in metabolic equivalents (METs) can be explained and only 50%-60% of participants were correctly classified as walking at a moderate intensity. Furthermore, these data suggest that individuals should walk $>100$ step/min$^{-1}$ to meet moderate intensity guidelines which equates to 3000 steps in 30 minutes on 5 days/week. This is actually
consistent with the estimate of 3000-4000 steps in 30 minutes reported in previous literature (Schneider, Crowder, Lukajic, & Bassett, 2003; Tudor-Locke & Meyers, 2001; Welk et al., 2000).

Currently, pedometer studies have been primarily used to distinguish between individuals who vary based on steps per day, to measure increases in physical activity in conjunction with an intervention, to conduct cross study comparisons with different populations, and to compare time trends in PA (Schneider, Crouter, & Bassett, 2004). The case has been made repeatedly that achieving the recommended amount of daily PA is effective and efficient in reducing the burden of chronic diseases (Kahn et al., 2002). Many interventions and strategies have been tested and evaluated, but dissemination to the populations that need guidelines most is still lacking. Brownson et al. (2007) argued that a gap occurs between intervention development and application where potentially effective interventions are not adopted and thus the positive effects are not seen in the communities for which they were developed. The authors described which factors played a role in state-level adoption of PA programs and also to characterized the stages of dissemination of evidence-based strategies promoting PA. A 25-item survey was administered to 52 PA contact people in all state health departments, Guam, and the Virgin Islands. Forty-nine (94%) surveys were returned and the most important factor chosen by the respondents as a determinant to implement a program was the availability of adequate resources (94%).

Evidence in literature suggests that aspects of the complex direct and indirect relationships between nutrition, PA, psychosocial constructs and the impact these variables have on health are quite important. Emerging statistical techniques are
becoming more available for use in social science research and thus present an opportunity for analysis that must not be ignored.
CHAPTER III
METHODOLOGY

The researcher used a latent growth curve analysis, also commonly referred to as a latent growth model (LGM), to investigate a theoretical model based on literature, behavior theory, and previous PA interventions. The model attempted to test the relationships among psychosocial attributes, health behaviors, and diet. Furthermore, attempts were made to estimate the degree to which several independent variables influenced the dependent variable in the context of the H.U.B. City Steps walking intervention. A secondary analysis attempted to incorporate a multiple regression to evaluate the accuracy of prediction of individuals who changed walking behaviors over the six month intervention period.

Sample

The sample was drawn entirely from the H.U.B. City Steps walking intervention which is a collaboration between the City of Hattiesburg, Mississippi, and The University of Southern Mississippi (USM) that focused on improving health in the greater Hattiesburg area by involvement of residents in regular walking activity. The study was funded by the National Institutes of Health (NIH) National Institute for Minority Health and Health Disparities (NIH R24MD002787); therefore, the primary recruitment efforts were directed toward African American residents experiencing health disparities.

H.U.B. City Steps staff recruited 24 volunteers from various neighborhoods around the targeted area to serve as walking group leaders (walking coaches). These walking coaches were chosen based on their ability to serve as leaders in the community and to motivate others to make health and fitness a priority. Preliminary recruitment
included networking within the community and following up with initial contacts. Once coaches were selected, they were trained and instructed to start recruiting community members for their groups. Recruitment was limited to the Hattiesburg city limits; therefore, participants with home addresses outside the city were excluded.

When the community members were recruited for the groups, pre-enrollment screening/registration forms were given to fill out and return to coaches; the coaches returned these forms to intervention staff. Participant information was entered into the database, and participants contacted staff to make an appointment for the enrollment health assessment. Any potential participant answering “yes” to any of six screening questions about poor or adverse health status was required to obtain a physician’s release in order to participate in the enrollment health assessment. Data collection was conducted at a central location secured by H.U.B. City Steps staff, and all data collectors were trained according to their assigned responsibilities. If an individual returned the contact form, made an appointment, and completed the enrollment health assessment they were then considered a H.U.B. City Steps participant. Enrollment concluded with a total of 267 participants consented and enrolled in the intervention.

Data

The goal of the outcome data collection for the H.U.B. City Steps program was to assess changes in physical, dietary, and psychosocial outcome measures in program participants. Data were collected every three months following baseline data collection and up to the point of randomization for the maintenance phase (0, 3, and 6 Months). Data collection instruments are included in Appendix B.
Variables and Instruments

Table 1 describes all the study variables used in analysis and construction of the latent growth model (LGM), while Figure 1 shows the proposed simple structure of the relationship between the health indicator and growth trajectories (slope and intercept) at 0, 3, and 6 months. A simple structure is presented in this manner so that the main analysis can be clarified prior to discussion of component parts. The slope in this figure represents the rate of change for a given individual over time while the intercept represents the status of an individual when all variables in the model are equal to zero, essentially the starting point for an individual. The health indicator latent variable was the time variant, dependent variable shown in Figure 2 and is indicated by the observed variables including systolic blood pressure (SBP), high density lipoprotein (HDL), body mass index (BMI), and blood glucose. The procedures used to gather this data are fully described below.

Next, Figures 3 and 4 show the latent variables socioeconomic and psychosocial status, and their respective components. Lastly, Figure 5 shows the complete model, a compilation of Figures 2 through 4, with all latent variables and observed variables, those that can be directly measured, included. This complete model explicitly distinguishes the latent variables, those represented with circles, from the observed variables, those represented by squares. Lines are used to delineate expected paths which posit the existence of a cause-effect relationship linking the variables so that the model can also provide information regarding the plausibility of these relationships actually existing.
### Table 1.

**Study Variables Proposed for Inclusion in Latent Growth Model**

<table>
<thead>
<tr>
<th>Construct/Variable</th>
<th>Abbreviation</th>
<th>Units</th>
<th>Variable Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health Indicator</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Mean Systolic Blood pressure</td>
<td>HI</td>
<td>N/A</td>
<td>Latent</td>
</tr>
<tr>
<td>b. Body Mass Index</td>
<td>SBP</td>
<td>mmHg</td>
<td>Continuous</td>
</tr>
<tr>
<td>c. High Density Lipoprotein</td>
<td>BMI</td>
<td>Ratio</td>
<td>Continuous</td>
</tr>
<tr>
<td>d. Glucose</td>
<td>HDL</td>
<td>mg/dL</td>
<td>Continuous</td>
</tr>
<tr>
<td>d. Glucose</td>
<td>BG1</td>
<td>mg/dL</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Socioeconomic Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Yearly Household Income</td>
<td>SES</td>
<td>N/A</td>
<td>Latent</td>
</tr>
<tr>
<td>b. Marital Status</td>
<td>Inc</td>
<td>Dollars</td>
<td>Interval</td>
</tr>
<tr>
<td>c. Education Level</td>
<td>Mar</td>
<td>N/A</td>
<td>Dichotomous (Married/Not Married)</td>
</tr>
<tr>
<td><strong>Psychosocial</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Social Support</td>
<td>Edu</td>
<td>N/A</td>
<td>Interval</td>
</tr>
<tr>
<td>b. Processes of Change</td>
<td>Psyc</td>
<td>N/A</td>
<td>Latent</td>
</tr>
<tr>
<td>c. Treatment Self-Regulation Diet</td>
<td>SS</td>
<td>N/A</td>
<td>Continuous</td>
</tr>
<tr>
<td>d. Treatment Self-Regulation Physical Activity</td>
<td>POC</td>
<td>N/A</td>
<td>Continuous</td>
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<tr>
<td><strong>Self-Reported Health Status</strong></td>
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<tr>
<td><strong>Coach Score</strong></td>
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<tr>
<td><strong>Food Frequency Questionnaire</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Improvement in walking behavior</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Delta_{steps}=X_{4,6}-X_{1,3})</td>
<td>Hlth</td>
<td>N/A</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Other Variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Race</td>
<td>Race</td>
<td>N/A</td>
<td>Dichotomous (African American/Non-African American)</td>
</tr>
<tr>
<td>b. Gender</td>
<td>Gen</td>
<td>N/A</td>
<td>Dichotomous (Male/Female)</td>
</tr>
</tbody>
</table>
Figure 1. Simplified Latent Growth Model. Model specifies a general schema for the LGM analysis where the dependent variable is the Health Indicator at each time point.

Figure 2. Dependent Variable (Health Indicator Latent Variable). Detailed depiction of the dependent variable and respective indicator variables.
Figure 3. Socioeconomic Status (SES) Latent Variable. The figure specifies the SES indicator variable and respective indicators included in the complete LGM.

Figure 4. Psychosocial Latent Variable. Depiction of the second order factor analysis for the psychosocial latent variable. Each first order construct is indicated by the second order variables.
Figure 5. Complete Latent Growth Model. The figure illustrates the LGM as proposed.

The outcome objectives of the intervention included: (a) increase PA of community members, (b) improve anthropometric and biological measures related to PA, and (c) improve psychosocial constructs related to PA behaviors. A description of the data derived from the intervention and used for this analysis follows:

*Health indicator.* The latent variable health indicator was comprised of SBP, HDL, BMI, and blood glucose. Systolic blood pressure was obtained by trained intervention staff at each data collection time period using an OMRON HEM-907XL automatic inflation sphygmomanometer. The sphygmomanometer automatically took two measurements, two minutes apart and the lower of the two measures was recorded. Waist circumference was measured using a Gulick model, unstretchable spring handle tape with
an ungraduated extremity of 3-5 cm in order to allow data collectors to properly grab the tape (Lee & Nieman, 2007).

Weight was measured using a Tanita Body fat analyzer model TBF-310. Protocol specified that participants would not wear shoes or socks, and would have feet cleaned with disinfecting alcohol wipes. The Tanita electrode foot pads were cleaned after each participant in order to ensure that there was no sand or other particles that might interfere with measurement. Participants were advised to wear light clothing to the assessment therefore the data collectors were instructed to enter 0.6 kg in the Tanita to account for a standard clothing weight. Height was measured in centimeters to one decimal place using a portable stadiometer (model, Perspective Enterprise Adult Infant Measurement [PE-AIM 101]). Body mass index was calculated from height and weight. Biochemical measures included cholesterol components and glucose which were analyzed using the Cholestech LDX Lipid Analyzer from a non-fasting blood sample collected through finger prick in a capillary tube of blood.

Socioeconomic status. The latent variable SES included the observed variables marital status, income, and education. These data were obtained from three questions on a 10-item interviewer-administered demographic questionnaire by trained intervention staff. Marital status and education questions were adapted from the 2000 Census questions (U. S. Department of Commerce, Economics and Statistical Administration, 2000). Income data was collected using modifications of the income categories from the National Health and Nutrition Examination Survey ([NHANES] Centers for Disease Control and Prevention, 2005b). The original NHANES question included categories for annual income greater than $55,000, but due to the population targeted by the H.U.B.
City Steps intervention, it was decided by research staff during the development phase that there was little need for such a large range of income values. Response options ranged from less than $5,000 to more than $55,000.

*Psychosocial measures.* The psychosocial latent variable was comprised of measures of Social Support (SS), Self-Efficacy, and Processes of Change (POC). The instrument measuring SS was interviewer administered and adapted from previous work of Russel and Cutrona (1984) called the Social Provisions Scale. The original instrument was composed of 24 questions and divided into six subscales which included: attachment, social integration, reassurance of worth, reliable alliance, guidance, and opportunity for nurturance. H.U.B. City Steps researchers adapted the instrument to consist of 23 questions divided into two sections with responses on a five-point Likert scale ranging from *strongly disagree* to *strongly agree*. The first section asked about SS received from the walking coach and contained three subscales (guidance, reliable alliance, and reassurance of worth) and the second section contained three subscales (guidance, reliable alliance, and social integration) derived from questions related to SS received from walking group members. Cognitive testing and pre-testing were conducted on the adapted instrument to ensure that it was appropriate for the target population. When the original scale was published (Cutrona & Russell, 1987) the authors stated it had been validated in several populations but not in low-income, ethnically diverse populations. Over years of development the scale has been validated for measuring PA social support (for review see Motl, Dishman, Saunders, Dowda, & Parte, 2004) in ethnically diverse populations (Motl et al., 2004) as well as low-income populations (Caron, Latimer, & Tougsignant, 2007). At baseline assessment the walking groups had not yet begun to
function, so participants were instructed to answer the best they could and an emphasis was placed on the acceptability of a neutral answer.

The POC was an interviewer administered measure using an instrument developed by Nigg et al. (2001). This instrument was developed for older adults and replicated in college students; internal consistency of this scale ranged from an alpha of .64-.86. The POC instrument consisted of 30 questions with responses on a five-point Likert scale ranging from never to always. There are 10 subscales scored independently and these subscales included stimulus control, social liberation, reinforcement management, helping relationships, counter conditioning, self-liberation, self-reevaluation, environmental reevaluation, dramatic relief, and consciousness raising.

Self-efficacy was an interviewer administered measure using an instrument from Ryan and Connell (1989). Bandura (1991) proposed and Cullen, Baranowski, and Smith (2001) agreed that self-regulation is a precursor to self-efficacy in that building confidence is done through focus on a specific behavior. The Treatment Self-Regulation Questionnaire (TSRQ) is composed of subscales assessing different forms of motivation: amotivation, external, introjection, identification and integration. This instrument was used across several BCC sites to measure self-regulation for behavior change and evidence provides validity and reliability of this measure for its consistency of use across studies of tobacco use, diet and PA (Levesque et al., 2007). H.U.B. City Steps researchers modified the TSRQ to best fit the target population, and cognitive testing as well as pre-testing was used to confirm its reliability. The final instrument contained 30-items divided into two sections with the first 15 statements focusing on exercise and PA while the last 15 statements focused on nutrition and diet. The instrument is constructed using
four subscales (introjected regulation, external regulation, autonomous motivation, and amotivation) with responses on a five-point Likert type scale ranging from *not at all true of me* to *very true of me*.

*Self-reported health status.* A self-reported health status question (1=Excellent, 5=Poor) was used and has been found to accurately predict mortality as well as serve as an indicator measure for chronic health conditions (Burstrom & Fredlund, 2001; Idler & Benyamini, 1997). While self-reported health ratings may be discounted if other, more objective health status indicators are present, these self-ratings may indeed be reliable predictors of health-related events.

*Coach quality score.* A coach quality score was assigned to each participant based on two measures related to her or his coach’s performance. These were total training hours (0-254) in which the coach participated, and a leadership survey score (6-150). Total training hours were considered to be an indication of the commitment of individual coaches to the project prior to beginning the intervention phase. Training included cardiopulmonary resuscitation (CPR) certification, intervention policy and procedures review, as well as SS, PA and nutrition education. Participation in total training hours was calculated by summing the total hours of training each coach participated in (range 5-254), and assigning one point for each training hour.

The Leadership Practices Inventory (LPI) was administered to only the walking coaches (n=24) and to 14 assistant walking coaches who were hired and trained subsequently, when additional funds became available, to assist the walking coaches with group leadership and motivation of participants in the H.U.B. City Steps research project. The LPI served as a reflection on coaching behavior during the active phase of the
intervention and is thoroughly described in the Review of Literature. The coach quality score was the sum of the two measures, and had a range of 6-404 points.

**Food frequency questionnaire.** The National Cancer Institute (NCI) Fruit and Vegetable Screener (National Institutes of Health, National Cancer Institute, 2005) was used to assess baseline as well as monitor any changes in fruit and vegetable, added sugar, fat and dairy/calcium consumption among participants. The NCI Screener, food frequency questionnaire (FFQ) was designed and validated to provide approximate intakes of percent energy from fat, added teaspoons of sugar, grams of fiber, milligrams of calcium, and servings of dairy and fruits and vegetables (National Institutes of Health, National Cancer Institute, 2005). The NCI Screener was slightly adapted by H.U.B. City Steps research staff and included 20 items that were interviewer administered. Questions regarding vitamin and mineral supplementation were excluded. For the most part, response options on consumption ranged from *never* to *5 or more times per day*; however, in one instance types of cereal consumed were identified so researchers could accurately estimate fiber intake.

While it was not the objective to assess total diet intake in this study, it was important to monitor selected changes in the usual diet as an evaluation measure in the context of the nutrition education sessions that were a part of the intervention, and related to the behavior modifications that were included and promoted as part of the education. The NCI Screener is ideal for this type of observation as it is known to provide a rough estimate of usual intake, although researchers have acknowledged that it is not as accurate as more detailed methods like food diaries (Greene et al., 2008). Another benefit of using the NCI Screener is that within the time limits of the overall health
assessment, which included several other measures, it is a brief, easily administered screener, reputable in capturing the three key components of the DASH diet, which was the focus of the nutrition education component of the intervention. Furthermore, validation research indicates that estimates may be useful to discriminate among individuals with regard to higher vs. lower intakes, and to allow examination of interrelationships between diet and other variables (Peterson et al., 2008).

The original NCI Screener tool was a five-factor screener but the factors were reduced to four in this application as it was deemed that the factors “dairy” and “calcium” were closely related such that only one was chosen to include in analyses. First, the participant responses were taken from the questionnaire and entered into formulas given by NCI to calculate the rough estimates of usual intake of fruits and vegetables (factor 1), fiber (factor 2), calcium (factor 3), and added sugar (factor 4) (National Institutes of Health, National Cancer Institute, 2005). The screener estimates of intake represent the frequency of foods consumed and while not as accurate as a 24-hour recall, median intakes to track changes over time are created. In order to calculate these median predicted amounts, a mathematical procedure was performed on the normally distributed version of the variable (i.e., Pyramid servings of fruits and vegetables was square-rooted; fiber was cube-rooted; calcium was quarter-rooted; and added sugar was cube-rooted). After analysis, the results were back-transformed (e.g. cubed, squared, etc.) to obtain estimates in the original units. Quantiles (other than median) of the distribution of intake in the sample population or estimate prevalence of attaining certain levels of dietary intake were estimated. Quantiles are useful measures because they are less susceptible to widely spread data and outliers. H.U.B. City Steps data was not distributed according to
the normal distribution, so the calculation of quantiles was a more useful descriptive statistic than the mean in this instance (Horn, 1990; Parzen, 1979).

For the purposes of this study, the variance-adjusted screener estimates of intake were taken and divided into quartiles. Quartiles of intake were established for each factor (1, 2, 3, and 4) and the data was re-coded. For example, using fiber, a variance-adjusted screener estimate of 1.1-2.0 was coded as 1 whereas 2.1-3.0 was coded as 2 and so on until intakes were evenly distributed among the four categories. Sugar intake was reverse coded into quartiles, as higher intake of sugar would indicate a negative behavior related to diet. Next, a total score was calculated for each participant by adding the factor quartiles for all four factors together to create a continuous variable, the range of which was 4-16. This total score acts as a measure of total diet quality which assumes that higher intakes are healthier than lower intakes.

*Improvement in walking behavior.* Each week, program participants maintained a weekly walking log by transferring daily step counts from their pedometers to a postcard or web-based form, which included goals and PA performed. Walking logs were submitted by participants via mail or through the website to research staff to be entered into the database. Summarized walking reports were prepared by research staff and given twice each month to coaches and monthly to participants. The completeness of each walking log was evaluated and if data for an individual over one week had fewer than three days of entry, the entire week was considered missing. To prepare data for analyses, the number of walking logs submitted was evaluated as well as overall compliance rates. For example, when examining the first 16 weeks of data, perfect compliance was defined as 112 daily step counts (calculated by multiplying 16 weeks of intervention by seven
days per week). In order to assess changes in steps/day, weekly averages were calculated based on the number of days reported so that no penalty was attached to missing days. For example, in a given week, if there were four days of steps reported then the total number of steps was divided by four instead of seven. Monthly averages were calculated for each participant so that changes in number of average steps per month over the six-month period of the intervention could be calculated. For the current project, improvement in walking behavior was indicated by taking the mean of the steps walked in months four through six and subtracting the mean of the steps walked in months one through three ($\Delta_{steps} = X_{4-6} - X_{1-3}$).

Data Management and Quality Control

All raw data obtained from participants was entered by the Data Coordinator and research assistants trained to do data entry into the Access database developed specifically for H.U.B. City Steps data. Excel for Windows was used to extract the data from Access and then data was imported into The Statistical Package for the Social Sciences (SPSS) system for Windows, version 18. Data was screened for inappropriate or missing values and outliers prior to extraction. However, once the data was imported into SPSS the researcher ran additional verification measures of central tendency to ensure full integrity of data. When necessary, data was recoded as deemed most appropriate for a particular analysis. For example, food frequency data, as described previously, was entered into the database from questionnaires, converted to variance-adjusted screener estimates and then calculated into quartiles; these quartile values were then used to recode variance-adjusted screener estimates into the proper quartile category (1, 2, 3, or
4) for each factor. A full description of each variable used in the latent growth model is shown in Table 1.

For LGM procedures, the MPlus software package (Muthen & Muthen, 1998-2011) was utilized to test the measurement model as well as structural model. The measurement model is a simple mapping of theoretical constructs with no paths indicating direction whereas a structural model is actually a specification of causal or correlational links between theoretical variables. MPlus allows the analysis of both cross-sectional and longitudinal data, single-level and multilevel data, and data that contain missing values (Muthen, 2004).

**Missing Data**

MPlus can operate using various options for the estimation of models with missing data and the program provides full information maximum likelihood (FIML) estimation under assumptions such as missing completely at random (MCAR) and missing at random ([MAR] Little & Rubin, 2002) for continuous variables. Missing at random indicates that missing variables could possibly be functions of observed outcomes while MCAR indicates that missing variables are not functions of either observed or unobserved data. Fortunately, when using Mplus, FIML is most often used since a missing variable could possibly be MCAR or MAR. Furthermore, with missing data, the convention is to compute standard errors for parameter estimates using the observed rather than the expected information (Kenward & Molenberghs, 1998). In this analysis FIML techniques were used to compute standard errors of parameter estimates. Imputation was necessary prior to modeling with MPlus and a linear trend analysis,
which is a regressive technique used to predict missing data points, was used since the study design called for an “intent to treat” analysis.

Statistical Analyses

Many research studies, including the one described herein, seek to measure change. The representation and measurement of change is fundamental in empirical research and the most common way to demonstrate behavior change is to employ a longitudinal design. The two ways to analyze longitudinal data are with autoregressive techniques (i.e., multiple regression) and growth curve models. The approaches are quite different and can produce different results. The decision on which method to employ is based on the nature of the questions being asked. For the current study, latent growth models were used with the longitudinal data to capitalize on individual differences in growth trajectories over time.

Latent growth modeling (LGM) shares much strength as well as some weaknesses with basic structural equation modeling (SEM). Some of the strengths include the capacity to test the fit of the hypotheses, incorporate time-variant covariates and develop a unique change trajectory. Weaknesses include the fact that samples must be somewhat large and data requirements are more stringent as it has to be balanced on time. The fact that data must be balanced on time infers that time points or spacing between these points must be similar. If the time difference varies, other approaches (i.e., repeated measures regression) may be more appropriate. However, this does not imply that there must be a point at which there is absence of intervention or “0,” simply that there must be at least three time periods that are similar in duration. The nature of the current study is that three
health assessments were performed at three month intervals, thereby meeting requirements.

Latent growth modeling uses an outcome variable (in this case, health indicator) that is measured at multiple time points (0, 3, and 6 months) to define a model in which multiple health outcomes and psychosocial constructs actually work together to exhibit different growth curve shapes for the outcome variable. The essence of LGM is that change over time is a process unique to each case and individual differences should be accounted for over time. However, using LGM also provides the ability to analyze process variables that exert effects on the rate of change of outcome variables. Latent growth modeling uses these features to provide a comprehensive model and capture vital group statistics that provide information for the study of group level change. Following the idea of studying individual change is the concept that in LGM a trajectory over time is established for each individual in a sample, and therefore, characteristics of the trajectory (i.e., slope) can be described as either linear, quadratic, cubed, etc. By using methods like LGM, flexibility in addressing questions about change is made simpler, thus allowing researchers to see the rate and points at which individuals are changing which can then influence theory development or testing procedures. By describing the trajectory of change and using individual, time-dependent observations, interventionists can allow for more targeted interventions that pinpoint behaviors at opportune times in order to prompt behavior change and sustainability.

The benefit of using LGM over conventional techniques like repeated measures analysis of variance (RMANOVA) is that while parameter estimates from both techniques may be similar, LGM actually provides more flexibility to look at nonlinear
effects. Adding to this concept is the idea that, for example, in a two class model, one class may have a linear growth on the outcome variable where another may have quadratic or cubed growth as discussed above.

Another significant advantage to the use of LGM is the ability to use all available data and not exclude cases list-wise. List-wise deletion may result in significant declines in sample size especially when using longitudinal data which often has larger percentages of missing values than cross-sectional data. Latent growth modeling uses FIML for missing data so that all available data for every individual is summed across persons and an obtained likelihood function is derived for the missing individual data.

The MPlus software package (Muthen & Muthen, 1998-2011) was utilized to test the measurement as well as structural models. All study variables were identified and computed as described in the Instruments and Variables section. Researchers were unable to utilize the chi-square test to evaluate the latent variable model because the model never converged. Despite the fact that a chi square was not used, it should still be acknowledged that chi square tests are very sensitive to sample size and with large samples may produce a significant value which would indicate a model should be rejected when in fact the differences are not due to chance. The assessment of multiple fit indices was also impossible in this study but would generally shed much more light on the acceptability of the proposed model than a chi square alone.

Each latent and observed variable was used as an independent variable to predict the dependent variable, health indicator. In addition, each was measured and reported at 0, 3, and 6 months (Figure 1). The complete structure is shown in Figure 5. It should be noted that all exogenous variables, those variables with no causal links (arrows) leading
to them from other variables in the model, were correlated with one another. This correlation was essential because of the idea that in reality, each exogenous variable has variance and accounting for all variance between the variables is essential.

The LGM included five correlated variables, three observed and two latent constructs (Figures 2, 3, and 4). The observed variables were the scores calculated for participant’s diet quality indicated by FFQ and coach quality score as well as the participant’s self-rated health status. The latent variables were SES (composed of income, marital status, and education level), and psychosocial (scales comprising POC, SS, and self efficacy). The psychosocial latent variable was intended to be a second order factor analysis in which researchers tried to determine if the psychosocial measures did in fact correlate well enough to provide evidence to use them as factors in a latent variable. Unfortunately the second order analysis did not work as intended so psychosocial variables were reduced to a first order confirmatory factor analysis in which all indicators were in fact related. These measures include self-reported data on POC, SS, and self-efficacy for diet and for physical activity (measured as treatment self-regulation for diet [TSRD] and physical activity [TSRPA]). The need for a second order factor analysis was because each construct had multiple scales within: POC (n=10), SS (n=6), TSRD (n=4), and TSRPA (n=4). Once the latent variable was confirmed, the psychosocial latent variable was deemed adequately representative of the four respective constructs previously described.

The secondary analysis in this research included a multiple regression (MR). This MR included the independent variables self-reported health status, POC, SS, and self-efficacy, where improvement in walking behavior was the dependent variable used to
predict a change in steps walked. The purpose was to establish which groups, using baseline data, have predictive ability for success or failure of walking within the confines of the intervention. In order to more precisely target populations for health promotion, predicting behavior changes in participants that have certain characteristics like, for example, higher social support and presence of chronic disease, are important to future frameworks and intervention development.

Unfortunately, the MR did not fit adequately so a cross-sectional SEM was developed for baseline measures. The SEM attempted to explain the potential impact an individual’s behavioral health history as well as physiologic condition may have on SBP. Socioeconomic status and psychosocial latent variables were used to predict health behaviors via health status and FFQ observed variables. Other observed variables included BMI, HDL, and blood glucose.

Evaluation of Model Fit

Estimation of LGM was carried out using maximum likelihood estimation with FIML to control for missing data in MPlus (Muthen, 2004). Goodness of fit tests determined if the model being tested should be accepted or rejected. These overall fit tests do not establish that particular paths within the model are significant; only after the model is accepted should the path coefficients be interpreted (Loehlin, 1992). There are at least four tests that are recommended for establishing goodness of fit. According to Duncan et al. (1999), these tests include chi-square, Root Mean Square Error of Approximation (RMSEA), comparative fit index (CFI), and Tucker-Lewis Index (TLI).

Unfortunately, no one test can be relied upon to infer appropriate model fit. For example, a chi-square test may be misleading if the model is complex, has a very large
sample size, or if the assumption of multivariate normality is violated (Duncan et al., 1999). The following criteria describe interpretation for the goodness of fit tests mentioned. A RMSEA has a possible range of 0-1 where a value of about .05 or less would suggest a close fit of the model in relation to the degrees of freedom (Browne & Cudek, 1993). It should be noted that a RMSEA value may be misleading when degrees of freedom and sample size are small; significance still may exist but RMSEA values improve as model complexity and sample size increase (Rigdon, 1996); however, this should not be a problem in this analysis. The possible range of the CFI is 0 to 1 where a CFI equal to or greater than .90 is needed to accept the model which would indicate that 90% of the covariation in the data can be reproduced by the given model. The CFI is one of the fit indexes less affected by sample size which makes it more robust to varying models. The next measure is the TLI. The possible range of the TLI is also 0-1 where a TLI close to 1 indicates a good fit. Hu and Bentler (1999) have suggested the TLI should be equal to or greater than .95, and that values below .90 indicate a need to respecify the model.
CHAPTER IV
MANUSCRIPT I: LATENT GROWTH MODELING OF A NUTRITION AND
PHYSICAL ACTIVITY INTERVENTION

Background

The health, economic, and social impacts of physical inactivity and unhealthy dietary patterns are quite significant and evidenced by the fact that only 3-4% of American adults follow all the dietary advice recommended by the Dietary Guidelines for Americans ([DGA]; Kohatsu, Robinson, & Torner, 2004), and specific subpopulations, including the rural South, are affected even more drastically (McCabe-Sellers et al., 2007). Furthermore, the majority of the people in the United States do not currently meet recommended amounts of physical activity (PA) and have not since the mid 1980s (U.S. Department of Health and Human Services [USDHS], 2008). As far back as 1961, publications emerged from the Framingham Heart Study about cardiovascular disease (CVD) risk factors in relation to diet (Kannel, Dawber, Kagan, Revotskie, & Stokes, 1961; Mann, Pearson, Gordon, & Dawber, 1962), and in 1967 PA was found to reduce the risk of heart disease and obesity as well as lack of PA to increase the risk of CVD (Kannel, 1967).

To address the discrepancy between health recommendations and actualized unhealthy patterns of PA and diet, community members in a small, urban area composed of a racially diverse population in Mississippi collaborated with University researchers to develop a community partnership focused on increasing PA. From this partnership a walking intervention was developed through a participatory research process, which encompassed three specific aims that included capacity building (to develop and assess
community capacity to promote PA and healthy food choices), \textit{intervention} (to test treatment effects on health indicators such as systolic blood pressure [SBP] and other biological and anthropometric variables among all walking participants), and \textit{maintenance} (to test the treatment effects of a sustained motivational enhancement via telephone on SBP and other health indicators). As fully described elsewhere, other details of the 6-month walking intervention, based in part upon findings from a feasibility and pilot study conducted previously (Zoellner et al., 2009), included improving PA and health through membership in walking teams, active promotion of self-monitoring via pedometers and walking logs, and monthly nutrition and PA educational sessions (Zoellner et al., 2011).

Walking teams, composed of a walking coach and 10-15 team members that reported to the coach, were a key feature of the intervention, intended to provide social support for PA among participants. Walking coaches were tasked with role modeling healthy behaviors, involving community members, and encouraging group members to be active in the intervention. Coaches were required to attend all six intervention nutrition education sessions and three data collection health assessments as well as to keep weekly time sheets that recorded phone calls and contacts with walking group members. Previous literature reported by Zoellner et al. (2009) indicated that a coach’s compliance rates with the prescribed intervention positively influenced the walking team members’ compliance. Very little other research regarding the concept of quantifying coach or leader influence on health behaviors of teammates in informal community settings is available in the health promotion research literature.
Baranowski and colleagues (1998) and Laitakari and colleagues (1996) have argued that interventions work by means of mediating variables and that current theoretical models do not sufficiently account for variability in targeted outcomes. The variety of individual variables, as well as group level variables, studied or manipulated in diet and PA behavioral research are quite complex. Baranowski and others (Baranowski, Anderson, & Carmack, 1998; Hansen & McNeal, 1996) suggest that low-powered analytical techniques that have been used in evaluating models of health behavior change may impose significant limits on the conclusions regarding effectiveness of interventions to produce lasting behavior changes. To address these limitations, structural equation modeling (SEM), an analysis technique that can handle a number of complex factors at once instead of dividing or categorizing variables for separate analyses, has become increasingly popular. Structural equation modeling extends the analysis of interrelationships beyond a confirmatory factor analysis (CFA) and actually shows the proposed model as a succession of equations which is analogous to running several multiple regression equations. Additionally, SEM allows for the description of direct and indirect effects among variables. While path analysis offers another analytical option, this technique has very restrictive assumptions and does not allow for use of latent variables (those not directly observable), which may be necessary to characterize complex behaviors. A primary advantage of SEM for behavioral researchers is the ability to assess all pathways of a relationship simultaneously even allowing dependent variables to become indicators in subsequent pathways.

Within SEM a technique exists called latent growth modeling (LGM). Latent growth models test systematic intraindividual and interindividual differences in measures
over multiple time points and then detail change in these variables over time (Duncan, Duncan, Strycker, Li, & Alpert, 1999; Muthén, 1997). In essence, the extent to which individuals change in a given timeframe (intraindividual), as well the patterns of and differences in these changes over time among the cohort (interindividual) are evaluated (Stull, 2008). Additionally, LGM allows for the examination of dynamic associations of behavior over time, rather than a static view of behavior as examined at one time point, which has been noted as a limitation throughout health behavior literature. The intent of this analysis was to examine longitudinal interrelationships of health outcomes over the course of a six-month intervention with individual and group level factors that might influence them, including static measures of coach leadership and SES as well as time variant measures likely to be influenced by the intervention, including psychosocial measures of diet and PA, estimated dietary intake, and self-perceived health status.

Methods

Sampling and Recruitment

The H.U.B. City Steps intervention phase was conducted between January and July of 2010. A full description of the methodology has been previously published (Zoellner et al., 2011). Participants included 267 individuals enrolled as either walking coaches (n=25) or walking group members (n=242) in a community based participatory research (CBPR) intervention focused on increasing PA and lowering blood pressure. Recruitment efforts were primarily directed toward African American residents; however race/ethnicity was not an exclusion factor. Eligibility criteria included 18 years of age or older, English-speaking, non-institutionalized, and residing within the geographic boundaries of the targeted community. Participants with blood pressure over 180/110 at
enrollment were directed to obtain immediate medical attention and were disqualified from participating; however, all other participants were eligible for study participation regardless of blood pressure and hypertension medication regimen. All phases of this research were approved by The University of Southern Mississippi’s Institutional Review Board (see Appendix A), and informed consent and a medical disclaimer were obtained from all participants upon enrollment into the study.

*Latent Growth Modeling: Defining Variables*

The simplified, hypothesized model is shown in Figure 6. The predictors or variables conceptualized as independent include psychosocial score latent variable, food frequency questionnaire (FFQ), self-rated health status, coach score, and the SES latent variable. The first three (psychosocial, FFQ, and self-rated health status) were time variant which indicates that these variables were measured at baseline, three month and six month assessments because they were hypothesized to be influenced by the intervention. Coach score and SES were time invariant, measured only at baseline. The outcome or dependent variable was a latent variable named health indicator and composed of the physiologic measures, hypothesized to change over the course of the intervention and thus measured at the three time points of interest.

*Health Indicator*

The term “health indicator” was chosen to represent the dependent variable that would help establish positive or negative change trajectory over the course of the six-month intervention for a group of health status measures thought to be likely influenced by the intervention. The measured variables used to construct the health indicator latent
variable were systolic blood pressure (SBP), blood glucose, high density lipoprotein (HDL), and body mass index (BMI).

Biologic measures were obtained by trained technicians. Systolic blood pressure was measured using an OMRON HEM-907XL automatic inflation sphygmomanometer. The sphygmomanometer automatically took two measurements, two minutes apart and the lower of the two measures was recorded.

Weight was measured using a Tanita Body fat analyzer model TBF-310. Participants were advised to wear light clothing to the assessment; technicians entered 0.6 kg in the Tanita prior to measurement to account for standard clothing weight. Height was measured in centimeters to one decimal place using a portable stadiometer (model, Perspective Enterprise Adult Infant Measurement) and recorded. Body mass index was calculated by the Tanita using programmed height and measured weight and recorded, along with weight, from the Tanita printout. Blood glucose and HDL cholesterol, along with total cholesterol, low density lipoprotein (LDL) cholesterol, and triglycerides, were analyzed using the Cholestech LDX Lipid Analyzer from a non-fasting blood sample collected through finger prick in a capillary tube of blood and recorded from the machine readout.

**Socioeconomic Status**

A number of sociodemographic characteristics, including sex, marital status, and income, have been shown to correlate with health outcome measures. An interviewer administered questionnaire was used to collect data on participants’ sex, ethnicity and race, age, education, household income, and previous medical history. Data on ethnicity and race, marital status, and education were collected using questions adapted from the
2000 Census questions (U. S. Department of Commerce, Economics and Statistical Administration, 2000). Income data were collected using modifications of the income categories from the National Health and Nutrition Examination Survey ([NHANES]; Centers for Disease Control, 2005b). The original NHANES question included categories for annual income greater than $55,000, but due to the population which the H.U.B. City Steps intervention targeted, the range was limited to 12 categories ranging from less than $5,000 to more than $55,000.

**Health Status**

A single question on self-rated health status (1=Excellent, 5=Poor) was interviewer-administered at the three intervention time points. This measure of self-rated health has been found to accurately predict mortality as well as serve as an indicator measure for chronic health conditions (Burstrom & Fredlund, 2001; Idler & Benyamini, 1997). A single question was chosen over lengthier measures of self-perceived health status or more comprehensive direct measures of health status to reduce respondent burden and accommodate the non-clinical community setting in which data was collected.

**Diet**

The impact of nutrition on health is quite substantial as evidenced by extensive literature produced each year regarding nutrition interventions and health related outcomes. Diet related chronic diseases disproportionately affect African Americans and those with low incomes (Carter-Pokras & Baquet, 2002). The National Cancer Institute’s (NCI) Five-Factor Screener was used to assess dietary intake at the three data collection time points over the course of the intervention. The chosen FFQ allows for evaluation of
the Dietary Approaches to Stop Hypertension (DASH) diet which was the focus of the nutrition education component of the intervention. This valid 18-item screener approximates intake of fruit and vegetable servings, grams of fiber, teaspoons of added sugar, milligrams of calcium, and dairy servings (Subar et al., 2001).

Food group and nutrient intakes for each dietary component were calculated according to guidance provided by the NCI (National Institutes of Health, National Cancer Institutes, 2005). To address the need to create a single measure of dietary intake suitable for an LGM analysis from intakes of dietary components based on differing metrics (i.e., grams of fiber vs. teaspoons of sugar), participant intakes for each component were divided into quartiles. Each participant was assigned a score for each component ranging from 1 to 4, based on that individual’s intake quartile. Next, a summative dietary intake score (range 4-16) was created for each participant for each time point by summing the quartile score for each of four dietary components: fruits and vegetables, fiber, added sugar, and calcium. Calcium intake was used in preference to dairy intake in the FFQ score because of the high rate of lactose intolerance, and avoidance of dairy product consumption, in the African American population targeted for the intervention. In summary, an FFQ score of four would indicate that the individual was in the lowest quartile for all dietary categories (sugar was reverse coded) and therefore had a diet low in the specific food/nutrient groups and high in sugar, whereas a score of 16 would indicate an individual was in the lowest quartile for sugar intake and the highest quartile for the other food/nutrient components.
Coach Score

Because of social support theoretical underpinning and the amount of responsibility walking coaches were tasked with, the coach’s ability to effectively lead a walking group was hypothesized to be a factor that could influence the health indicator trajectory in the intervention. The coach score for each coach was calculated then applied to the coach’s respective group members for the analysis. The coach quality score was the sum of two measures. These were total hours of training received in preparation for the intervention (range 5-254) and score on the Leadership Practices Inventory ([LPI, range 0-150]; Kouzes & Posner, 1988). Total training hours were assumed to reflect the commitment of individual coaches to the project prior to beginning the intervention phase, as well as serving as a measure of the magnitude and variety of training actually received. Training included cardiopulmonary resuscitation (CPR) certification, intervention policy and procedures review, and content related to providing social support to group members, physical activity techniques and safety, and nutrition education. Each coach’s training score was calculated by summing the total hours of training each coach participated in, and assigning one point for each training hour.

The participant contact and role modeling expected from each walking coach is representative of the dimensions of leadership measured by the LPI. The LPI contained thirty statements; six statements each measuring five different constructs that represent practices of “exemplary leaders.” Each statement was cast on a five-point Likert scale where a higher value represented more frequent use of positive leadership behavior (range: 6-30 for each construct). In other literature, specifically athletic training and nursing, reliability measures for the LPI constructs were consistently between 0.75 and
0.87 and the five factors were extracted with eigenvalues greater than 1.0 and accounted for 60.5 percent of the variance (Carless, 2001). The LPI was administered to each coach (n=24) after training and prior to the end of the intervention. Because skill at leading a walking group might be expected to develop over time, assessment of the LPI was completed at the end of the active intervention.

**Psychosocial Measures**

Studies based on theoretical models of health behavior change have demonstrated that social support, readiness to change, and self-efficacy may be powerful determinants of improvements in health behaviors (Schwarzer et al., 2007). Therefore, previously validated psychosocial instruments were selected and adapted for this study and included social support for physical activity (Russell & Cutrona, 1984), treatment self-regulation for physical activity (TSRPA) and for diet (TSRD; Levesque et al., 2007), and processes of change (POC) for physical activity (Marcus, Rossi, Selby, Niaura, & Abrams, 1992). The adapted instruments included physical activity social support from coaches (11 items, three sub-scales: guidance, reliable alliance, reassurance of worth); physical activity social support from walking group members (12 items, three sub-scales: guidance, reliable alliance, social integration); treatment self-regulation for diet and physical activity (15 items each, four sub-scales each: amotivation, external, introjection, identification and integration); and processes of change (30 items, 10 subscales: stimulus control, social liberation, reinforcement management, helping relationships, counter conditioning, self-liberation, self-reevaluation, environmental reevaluation, dramatic relief, and consciousness raising). Cognitive testing and pre-testing were conducted on the adapted instruments to ensure that they were appropriate for the target population. On
the baseline data, the majority (24 of 29) of scales and subscales demonstrated strong internal consistency with Cronbach’s alphas ≥ .70 when item composition was maintained from the intended item clustering. Moderate internal consistency with Cronbach’s alphas ranging from .44-.63 was noted for five scales including amotivation for physical activity, amotivation for diet, dramatic relief, self-liberation, and social liberation.

Initially, the psychosocial latent variable was hypothesized as a second order factor analysis because each construct consisted of multiple scales within: social support (n=6), TSRD (n=4), TSRPA (n=4) and POC (n=10). The scales within each construct were tested via CFA, but there was not an acceptable second order model solution using the study sample at baseline. The psychosocial latent variable was redefined as a four indicator latent variable using total scale scores as the identifier for each construct, resulting in a CFA that was acceptable.

Analysis

The intent of the analysis was to examine longitudinal interrelationships among the predictor variables (psychosocial, FFQ, self-rated health, SES, and coach score) and the outcome variable, health indicator, using latent growth modeling (LGM) conducted with MPlus version 6 (Muthen & Muthen, 1998-2011). The growth trajectories of predictor variables over a period of six months were modeled. Scores for the psychosocial variables and food frequency were taken at baseline, three months, and six months and were used as time-variant variables. Variables that were time-invariant were SES and coach score. The outcome variables, indicated by the latent variable, health indicator, included blood glucose, BMI, HDL, and SBP and were measured at all three time periods (Table 1).
The analyses included the 267 women and men for whom all baseline data was present. If all baseline data were present, linear interpolation was conducted on variables of interest at three and six months since not all 267 participants returned for follow-up assessments. Missing data was evaluated and no significant differences were found in those participants that returned and those that did not return for three month (returned, n=227) and six month (returned, n=190) follow-ups; therefore, the data was deemed missing completely at random which historically allows for data imputation (Gadbury, Coffey, & Allison, 2003). The maximum likelihood (MLM) parameter, also referred to as the Satorra-Bentler chi-square (Satorra & Bentler, 1988, 2010), was used because it estimates with standard errors and a mean-adjusted chi-square test statistic that is robust to non-normality.

Results

Of 267 enrolled participants, most were African American (94%) females (85%; Table 2) with a mean age of 43.8 (SD=12.1) years (Table 3). More than half of the participants were single (58%) and had obtained at least a college degree (52.3%). Almost half (48.3%) reported a “good” health status while 41.6% had been diagnosed with high blood pressure.

Model Modification and Presentation

Construction of the LGM (Figure 1) first required confirmatory factor analysis on the latent variables included within the model. The first was the psychosocial latent variable ($X^2=2.958$, degrees of freedom [df]=2, $p=0.228$; TLI=0.991; CFI=0.997; RMSEA=0.042 [CI 90%= 0.000-0.136]) and then the SES latent variable which was just identified by its three indicator variables which meant no fit statistics could be generated.
Finally, the dependent variable was defined as latent and included four biological measures. The CFA of the dependent variable never converged and thus the LGM for the entire model did not converge.

Because of negative error variance, the error variances for the indicators of the dependent variable were constrained to be equal in an attempt to correct the issue. Unfortunately, this corrective technique that has proven useful to other researchers (Byrne, 2010) was unsuccessful and the model solution remained inadmissible. The indicators of the dependent variable were then converted to factor scores. Factor scores were estimated by summing raw scores on each individual’s characteristics within the dependent latent variable (HDL, SBP, glucose, and BMI). These factors were then placed in the dataset and used as the data points for estimation within the CFA of the dependent variable. This technique was thought to potentially have benefit since the physiologic characteristics measured within the latent variable were on differing scales. The final method used in an attempt to reach convergence was to rescale the variables. Variance of each variable was assessed and by the recommendation of the Director of Product Development at MPlus, recalculated by dividing by a constant to yield a value between 1-10 (personal communication, Muthen, L., 2011).

After attempting to run the complete model following these modifications, non-convergence resulted. Skewness and kurtosis statistics were re-examined for each variable to assess normality and outliers. At this point, there were no obvious outliers. After all corrective actions had been exhausted, the simplest LGM was run, which was a test of the dependent variable at 0, 3, and 6 months. The LGM did not converge at this simple level despite the fact that some individual CFA’s were indicative of acceptable fit
for each individual dependent variable at time points independent of one another and of other variables. For example, fit indices for the CFA of the health indicator dependent variable were good at three months ($X^2=2.068$, degrees of freedom [df]=2, $p=0.356$; TLI=0.990; CFI=0.997; RMSEA=0.011[CI 90%=0.000-0.122]), but not at baseline ($X^2=1.70$, degrees of freedom [df]=2, $p=0.428$; TLI=1.064; CFI=1.000; RMSEA=0.000 [CI 90%=0.000-0.116]).

Discussion

The overall intent of this analysis was to examine longitudinal interrelationships among measured participant characteristics using LGM; however, this analytical approach was unsuccessful. An example of a specific hypothesis included evaluating the growth trajectories of participants in relation to self-reported health status in order to determine if perception of health status exhibited relationships with the rates at which health outcomes changed. For example, would an individual who reported poor health be more likely to improve SBP at a faster rate than an individual who reported good health? The trajectories of interest included SBP, glucose, BMI, and total cholesterol. Another question of significance was the idea of linear variability. In essence, are individuals changing at the same rate between measurement periods or is change accelerated during the initial phases of the intervention while slowing during the latter phases. Unfortunately, the inadmissible solutions generated by the dependent variable of the LGM prohibit these questions from being answered.

The reason why the solution was inadmissible remains to be discovered. An article by Fan and Fan (2005) articulated that more measurement periods are probably better because the minimum allowable in LGM is three points due to the need to detect a
fixed magnitude of linear growth. While the optimum number is not defined, more than three time points would more than likely have been beneficial in this analysis because more repeated measurements provide more precise estimates given the residuals needed to model growth. Fan and Fan discussed convergence in SEM and with the estimations they reported, 100% of samples with between five and nine time points converged whereas samples with only three time points did not converge 40% of the time. These authors suggested that longitudinal studies should be designed to incorporate more than three measurements when researchers plan to do any type of SEM with the data. Interestingly, they noted as have other researchers (Boomsma, 1985; Guo, Perron & Gillespie, 2009) that sample size did not seem to play a role in nonconvergence.

In addition to a limited number of repeated measurements included within the LGM, a concern noted by McArdle and Bell (2000) is that research of developmental trends often shows that early measures tend to have smaller variances than later measures. In essence, individuals become increasingly different as they develop over time, which can cause problems when trying to estimate linear growth. These barriers and likely others did not allow for convergence of the model presented within this paper and similar issues might be occurring in other research without reports of non-convergence being published.

In particular, relatively few articles have been published within health behavior, specifically nutrition and physical activity literature, using LGM techniques as the primary form of data analysis. A few examples include testing measurement invariance (Nigg, Lippke, & Maddock, 2009; Paxton et al., 2008), mediation and moderation (Dutton, Napolitano, Whiteley, & Marcus, 2008; Roesch, Norman, Villodas, Sallis, &
Patrick, 2010; Schwarzer et al., 2007), and process evaluation (Hess, 2000). One of the first articles to address the novelty of using LGM within health behaviors was reported by Duncan and McCauley (1993). These authors looked at self-efficacy in terms of the mediational role it may play in conjunction with social support to change exercise behaviors.

It is notable that more recently, researchers within health behavior have begun calling for more advanced statistical methods and analyses. For example, Dunn, Resnicow, and Klesges (2006) called for advancing psychometric properties of measurement specific to health behavior and chronic disease while Cerin, Taylor, Leslie, and Owen (2006) identified the need for more powerful methods of analysis on mediation with a specific example of a walking intervention with social support. Within the discipline of nutrition, there are very limited reports of either SEM or LGM to test causal hypotheses. It is interesting to note the lack of reported SEM and LGM research because other behaviors like alcohol and drug dependence or academic achievement have many published reports of structural models that describe and even define behavior constructs based on individual trajectories. A review of SEM performed in the social work literature noted that between 2001 and 2007 only one of 32 studies used LGM as an analysis and these researchers used MPlus, the program used within this research, to perform LGM. Guo, Perron, and Gillespie (2009) also noted that no studies reported final models that lacked a good fit which suggests that authors may be exhausting model modifications in order to avoid reporting negative findings. This leads to the idea that the analysis modifications may in some sense negate important knowledge gains that could be used from non-significant findings.
A recent article by Chavance et al. (2010) focused on building SEM to analyze eating behavior and adiposity models. In this article, Chavance and colleagues referred to the fact that although SEM has been used in several fields of social science research, the field of epidemiology, and specifically nutritional epidemiology, is not as readily integrating SEM into data analyses. Additionally, several authors have called for the use of more advanced multivariate techniques (Baranowski, Lin, Wetter, Resnicow, & Hearn, 1997; Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003; Cerin, Taylor, Leslie, & Owen, 2006; Dunn, Resnicow, & Klesges, 2006; Masse, Dassa, Gauvin, Giles-Corti, & Motl, 2002). Unfortunately, reports where models do not converge or where insignificant findings are present seem to not be published, and therefore, a gap in literature is being perpetuated. Several reasons insignificant SEM findings may not be reported exist, and one may be that this technique is not widely accepted and programs capable of performing these analyses are hard to use or perhaps the cause is negative or non-significant findings that do not get reported as suggested previously.

With the emphasis placed on new techniques to enhance or further develop statistical methodology, there is also an emphasis from funding agencies to produce quality research that can be translated into other settings to address various health disparities. Application of analytical techniques such as LGM may yield greater understanding of the behavior change process, and thus contribute to translation of more cost-effective intervention research approaches to community based programs and population based interventions.
Conclusions

While many interventions have attempted to ascertain the underlying mechanisms by which behavior can be changed, and multiple PA interventions have incorporated behavior change theories in their development, these studies have not focused on understanding the mechanisms of change, nor have they used a multidisciplinary perspective to understand the process. Understanding the psychosocial, environmental, and physiological factors that affect the mechanisms of behavior change is necessary for developing effective interventions. It is imperative to target correlates that are in the causal pathways of PA behavior change and not waste time on resources and interventions that deal with variables not directly related to PA behavior change (Kraemer, Stice, Kazdin, Offord, & Kupfer, 2001).

Many studies have examined the predictive ability of consuming certain foods or performing certain activities in relation to sedentary lifestyle or obesity. These studies typically use a form of regression to assign probabilities to certain groups. Multiple regression analysis is limited by several assumptions that PA and food frequency data often do not meet; for example, linearity and normality. Linearity is a specific concern for this type of data as linear relationships predict constant change when in fact health behaviors may follow a more time dependent change in which change trajectories are very informative. For example, in the case of an intervention like H.U.B. City Steps, greater change in outcome measures may be seen between the first and second health assessments than between the second and third assessments.

In conclusion, statistical methods that rely on linear techniques are not adequate for all health behavior research but the ability to use more advanced auto-regressive
techniques is still developing. A particular methodological challenge occurring in health behavior research, specifically with regard to physical activity and nutrition behaviors, is to find an analysis or group of analyses that can be performed in the social ecological context of behavior and health but also appropriately analyze outcomes from a perspective that is feasible and theory driven. Hierarchical linear modeling (HLM) may be a good option because it allows for nesting of participants in groups. Often used in education and business literature, HLM describes participants in the context of, for example, the family to which they belong, the walking group, and ultimately the community. The HLM technique could also benefit analysis of longitudinal datasets by allowing time-series data to be used as a nest so that frequency or number of measures is not an issue as is with LGM.
**Figure 6.** Latent Growth Model.
Table 2.

*Characteristics of Study Sample (Manuscript I; N=267).*

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>40</td>
<td>15.0%</td>
</tr>
<tr>
<td>Female</td>
<td>227</td>
<td>85.0%</td>
</tr>
<tr>
<td><strong>Race</strong></td>
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<td></td>
</tr>
<tr>
<td>Black or African American</td>
<td>252</td>
<td>94.4%</td>
</tr>
<tr>
<td>White</td>
<td>14</td>
<td>5.2%</td>
</tr>
<tr>
<td>American India or Alaska native</td>
<td>1</td>
<td>0.4%</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;11th grade</td>
<td>12</td>
<td>4.5%</td>
</tr>
<tr>
<td>12 grade (high school grad/GED)</td>
<td>41</td>
<td>15.4%</td>
</tr>
<tr>
<td>Trade or VOC school</td>
<td>13</td>
<td>4.9%</td>
</tr>
<tr>
<td>Some college</td>
<td>61</td>
<td>22.8%</td>
</tr>
<tr>
<td>College degree</td>
<td>75</td>
<td>28.1%</td>
</tr>
<tr>
<td>Some graduate or professional school</td>
<td>19</td>
<td>7.1%</td>
</tr>
<tr>
<td>Graduate level or professional degree</td>
<td>46</td>
<td>17.2%</td>
</tr>
<tr>
<td><strong>Total income in the last 12 months</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than $9,999</td>
<td>39</td>
<td>14.6%</td>
</tr>
<tr>
<td>$10,000-$19,999</td>
<td>35</td>
<td>13.1%</td>
</tr>
<tr>
<td>$20,000-$29,999</td>
<td>54</td>
<td>20.2%</td>
</tr>
<tr>
<td>$30,000-$39,999</td>
<td>37</td>
<td>13.9%</td>
</tr>
<tr>
<td>$40,000-$49,999</td>
<td>30</td>
<td>11.2%</td>
</tr>
<tr>
<td>≥$50,000</td>
<td>71</td>
<td>26.4%</td>
</tr>
<tr>
<td>Don’t Know</td>
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<td>0.4%</td>
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<tr>
<td><strong>Marital status</strong></td>
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<td></td>
</tr>
<tr>
<td>Now married</td>
<td>113</td>
<td>42.3%</td>
</tr>
<tr>
<td>Widowed</td>
<td>12</td>
<td>4.5%</td>
</tr>
<tr>
<td>Divorced</td>
<td>46</td>
<td>17.2%</td>
</tr>
<tr>
<td>Separated</td>
<td>7</td>
<td>2.6%</td>
</tr>
<tr>
<td>Never married</td>
<td>89</td>
<td>33.3%</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
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<td></td>
</tr>
<tr>
<td>Normal (18.5-24.9)</td>
<td>25</td>
<td>9.5%</td>
</tr>
<tr>
<td>Overweight (25-29.9)</td>
<td>52</td>
<td>19.5%</td>
</tr>
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</table>
Table 2. (cont.)

<table>
<thead>
<tr>
<th>Health status</th>
<th>76</th>
<th>28.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obese (30-34.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morbidly obese (≥35)</td>
<td>114</td>
<td>42.6%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>19</td>
<td>7.1%</td>
</tr>
<tr>
<td>Very Good</td>
<td>54</td>
<td>20.2%</td>
</tr>
<tr>
<td>Good</td>
<td>130</td>
<td>48.7%</td>
</tr>
<tr>
<td>Fair</td>
<td>58</td>
<td>21.7%</td>
</tr>
<tr>
<td>Poor</td>
<td>6</td>
<td>2.2%</td>
</tr>
</tbody>
</table>

Note. SD=standard deviation.

Table 3.

Means and Standard Deviations of Variables Used in Latent Growth Model (Manuscript I; N=267).

<table>
<thead>
<tr>
<th>Construct/Variable</th>
<th>Zero Month Mean (SD)</th>
<th>Three Month Mean (SD)</th>
<th>Six Month Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Indicator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean Systolic Blood pressure</td>
<td>125.92 (19.15)</td>
<td>120.62 (16.46)</td>
<td>119.46 (13.31)</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>34.64 (8.19)</td>
<td>34.50 (7.21)</td>
<td>33.78 (6.27)</td>
</tr>
<tr>
<td>High Density Lipoprotein</td>
<td>51.88 (15.00)</td>
<td>51.19 (13.12)</td>
<td>49.83 (12.68)</td>
</tr>
<tr>
<td>Glucose</td>
<td>102.16 (27.46)</td>
<td>104.89 (38.87)</td>
<td>103.59 (34.90)</td>
</tr>
<tr>
<td>Psychosocial</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Support</td>
<td>94.12 (15.05)</td>
<td>98.66 (13.40)</td>
<td>98.30 (12.86)</td>
</tr>
<tr>
<td>Processes of Change</td>
<td>106.49 (16.81)</td>
<td>113.24 (15.16)</td>
<td>113.61 (13.95)</td>
</tr>
<tr>
<td>Self-Efficacy Diet</td>
<td>50.27 (8.65)</td>
<td>49.41 (7.77)</td>
<td>48.79 (7.37)</td>
</tr>
<tr>
<td>Self-Efficacy Physical Activity</td>
<td>51.19 (7.78)</td>
<td>50.32 (7.27)</td>
<td>49.87 (7.29)</td>
</tr>
<tr>
<td>Self-Reported Health Status</td>
<td>2.92 (0.89)</td>
<td>2.73 (0.78)</td>
<td>2.70 (0.70)</td>
</tr>
<tr>
<td>Food Frequency Questionnaire</td>
<td>9.99 (2.68)</td>
<td>9.72 (2.69)</td>
<td>9.76 (2.79)</td>
</tr>
<tr>
<td>Coach Score</td>
<td>252.30 (85.06)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mean±SD)</td>
<td>43.8(12.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. Social support range= 23-115, processes of change range= 30-150, self-efficacy diet range= 15-75, self-efficacy physical activity range=15-75, self-reported health status range 1-5; food frequency questionnaire range= 4-26, coach score range= 6-404.
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*Journal of Epidemiology in Community Health, 55*, 836-840. doi:10.1136/jech.55.11.836


CHAPTER V
MANUSCRIPT II: INFLUENCE OF PSYCHOSOCIAL AND PHYSIOLOGIC FACTORS AND SOCIOECONOMIC STATUS ON SYSTOLIC BLOOD PRESSURE IN AN AFRICAN AMERICAN POPULATION

Introduction

According to the National Health and Nutrition Examination Survey (NHANES) 2005-2006, hypertension affected more than 65 million people in the United States with a disproportionate amount being African Americans (Egan, Zhao, & Axon, 2010). Furthermore, Egan, Zhao, and Axon (2010) found that hypertension control improved over time for all groups, from 27.3% in 1988-1994 to 50.1% in 2007-2008; yet, racial health disparities in hypertension prevalence still existed, with African American rates being greater than Caucasian individuals. Health disparate populations, as defined by the Health Care Fairness Act of 2000 (HR 3250), include those with significantly higher overall rates of disease incidence as compared to the general population, and factors that impact disparities include socioeconomic status (SES), lifestyle, cultural and physical environments and living and working conditions (HR 3250, 2000). Geographic and economic disparities also exist as the Centers for Disease Control (CDC; 2003) reported that adults with incomes ≤ $10,000 had the highest prevalence (52.5%) of multiple heart disease risk factors while states in the deep south made up 6 of the 12 states/territories with ≥40% of the population having multiple heart disease risk factors. Given that addressing and reducing health disparities remains a public health priority (U. S. Department of Health and Human Services, 2010), efforts are needed to more thoroughly understand why health disparities persist for hypertension. While it is well recognized
that health and disease are impacted by biological, psychological, and behavioral factors, the current literature is limited by the lack of comprehensive modeling to understand these complex interactions. The Institute of Medicine (IOM, 2001) report on health and behavior stated that in order to understand and influence health behaviors the recognition that health and disease are determined by interactions of biology, psychology, and behavioral factors must be present. While this report did not indicate to what degree psychological or psychosocial and behavioral factors impact health or how the variables should be accounted for or treated within a comprehensive model, the acknowledgement that components of health are complex variables and the interactions between the variables impact health outcomes is quite valuable.

According to the CDC (2009), several physiologic factors increase the risk for cardiovascular disease (CVD), and more specifically, hypertension. Obesity is one factor and is most often indicated by Body Mass Index (BMI). The prevalence of high blood pressure increases progressively with increased BMI; for adults with BMI \( \geq 30 \) hypertension prevalence is 41.9% for men and 37.8% for women, compared with 14.9% percent and 15.2% , respectively, with BMI \( \leq 25 \) (CDC, 2009). Physiologic variables like blood glucose and cholesterol levels are also part of the constellation of risk factors significantly related to hypertension. Some evidence indicated that increased blood glucose may lead to increased blood pressure and by lowering both, risk for microvascular complications decreases (De Boer et al., 2008). Furthermore, lower levels of high density lipoproteins (HDL) are associated with higher blood pressure (Sakurai et al., 2011).
Health behaviors like diet and physical activity have been known to influence health for years, and specifically, diet is an important health behavior to assess when considering hypertension. Dietary Approaches to Stop Hypertension (DASH) is a diet plan emphasizing fruits and vegetables, along with low fat dairy foods. The DASH diet has been shown to lower blood pressure and influence other positive health outcomes; for example, increased intake of fruits and vegetables as well as fiber and calcium have been shown to lower blood pressure (Carter, Gray, Troughton, Khunti, & Davies, 2010; Liu et al., 2000; Van’t, Jansen, Klerk, & Kok, 2000). The combination of following the DASH diet regimen and being physically active promotes reduction of blood pressure and prevention of hypertension (Elmer et al., 2006).

As physiologic and behavioral factors seem to directly influence blood pressure, sociodemographic characteristics may also impact an individual’s blood pressure whether directly or indirectly. Sociodemographic characteristics include sex, marital status, and income and have been shown to correlate with health outcomes including blood pressure. For example, better health outcomes are associated with increased income, and a higher level of education, as well as with residence in higher income neighborhoods. A systematic review of literature published from 1966-1996 found that lower SES, among other factors, was associated with increased blood pressure in almost all studies conducted within developed countries (Colhoun, Hemingway, & Poulter, 1998).

There is a rich body of literature examining relationships of various psychosocial factors to health outcomes, both cross-sectionally and in the context of behavioral interventions. The influence of social relationships on health has been studied cross-sectionally since the early 1970s (Cohen, 2004) and has more recently been used in
longitudinal research to demonstrate that a lack of social support is a risk factor for mortality (Brummet et al., 2005). Several authors found that immune response, cardiovascular systems and other health related behaviors are related to social support and social integration (Michael, Berkman, Colditz, Holmes, & Kawachi, 2002; Seeman, 2000).

Self-efficacy has also been linked to favorable health outcomes (Gecas, 1989) through its relationship to positive health behaviors. Self-efficacy is an individual’s confidence or belief in his or her ability to perform a certain behavior (Bandura, 1977). According to Bandura (1997), the theory of self-efficacy posits that the greater degree to which one believes he or she can perform an action (or behavior), the more likely he or she will begin the action and persevere.

An extensive body of literature on the Trans-Theoretical Model (TTM) suggests that individuals use psychological processes of change to move through stages of behavioral change leading to improved health outcomes. Cognitive, evaluative, and affective processes such as consciousness raising are applied in earlier change stages, whereas behavioral processes such as contingency management and stimulus control can foster behavior change in later stages (Glanz, Rimer, & Viswanath, 2008). The relationship of perceived health status to actual health outcomes is also of interest. A study dating back to 1971 indicated that self-rated health is second only to age in its power to predict morbidity and mortality (Mossey & Shapiro, 1982). However, recent work of Brandon and Proctor (2010) found that southern African Americans’ self-perception of health was poorer than that of Caucasians, and that data on their actual health status did not entirely support this perception. Research also supports the idea that
self perception of health is also related to social support and social integration. In a study by White, Philogene, Fine and Sinha (2009), older persons that reported adequate social support were more than two and a half times likely to report good health (95% CI=1.5, 5.01; P<.001) than older persons with no friends. Perceived physical health seems to be related to health outcomes but may be influenced by race/ethnicity-related and psychosocial factors.

Associations between race/ethnicity and hypertension have been established, but these associations may or may not look the same in a more complex or multi-dimensional context. Consideration of other variables that may mediate or moderate effects of race, such as those discussed previously, can be considered using complex analytical techniques such as structural equation modeling (SEM). Structural equation modeling can be described as a mixture of multiple regression and exploratory factor analysis (Ullman, 2001). While path analysis is an important tool, the use of single indicators to represent latent constructs as well as the inability to test recursive relationships between variables across the model is limiting. The current study used a SEM to examine the impact that several socioeconomic status (SES; annual household income, marital status, educational attainment), psychosocial (social support, processes of change, self efficacy), physiologic (BMI, blood glucose, HDL) and health behavior (Food Frequency) variables, as well as perceived health status, have on blood pressure.

Methods

Participants included 267 individuals enrolled as either walking coaches (n=25) or walking group members (n=242) in a community based participatory research (CBPR) intervention focused on increasing physical activity and lowering blood pressure.
Recruitment efforts were primarily directed toward African American residents; however, race/ethnicity was not an exclusion factor. Eligibility criteria included participants who were 18 years of age or older, English-speaking, non-institutionalized, and residing in the immediate community within the small southern city of Hattiesburg, MS. Hattiesburg has a median income of $24,409 and is 47.34% African American (U. S. Census Bureau, 2007). Participants with blood pressure ≥180/110 mm/Hg were directed to obtain immediate medical attention and were disqualified from participating; however, all other participants were eligible for study participation regardless of blood pressure and hypertension medication regimen.

Measures

All measures were gathered at baseline, prior to the start of the intervention, following procedures set forth in a data collection manual of procedures developed to detail standardized guidelines for assessment. Data collection occurred at a local community center purposefully selected for its convenient location to study participants. All data collectors were specifically trained on study assessment protocols and required to demonstrate proficiency to the data collection coordinator.

Dietary intake. Dietary behavior was measured using the National Cancer Institute’s (NCI) Five-Factor Screener. This valid 18-item screener approximates intake of fruits and vegetable servings, grams of fiber, teaspoons of added sugar, milligrams of calcium, and dairy servings (Subar et al., 2001). The chosen food frequency questionnaire (FFQ) allowed for characterization of participants into groups based on higher vs. lower intakes as well as examination of relationships between diet and other variables (NIH,
The FFQ variable was included as an exogenous, observed variable within the SEM.

**Self-reported health status.** Self-reported health status was measured using a single question, with responses ranging from 1=Excellent to 5=Poor. Ratings were reverse-coded for the analysis, such that a higher score reflected a higher rating of personal health. Self-reported health rating or status has been found to accurately predict mortality as well as serve as an indicator measure for chronic health conditions (Burstrom & Fredlund, 2001; Idler & Benyamini, 1997).

**Physiologic variables.** Systolic and diastolic blood pressures were assessed using an OMRON HEM-907XL automatic inflation sphygmomanometer. Weight was gathered using a Tanita Body fat analyzer model TBF-310. Height was measured in centimeters to one decimal place using a portable stadiometer (model, Perspective Enterprise Adult Infant Measurement). Body mass index was calculated from height and weight. Biochemical measures included glucose and HDL which were determined using the Cholestech LDX Lipid Analyzer from a non-fasting blood sample collected through finger prick in a capillary tube.

**Socioeconomic status.** An interviewer-administered questionnaire was used to collect data on participants’ ethnicity and race, age, education, household income, and previous medical history. Marital status and education questions were adapted from 2000 Census questions (U. S. Department of Commerce, Economics and Statistical Administration, 2000). Income data were collected using modifications of the income categories from the National Health and Nutrition Examination Survey ([NHANES] Centers for Disease Control and Prevention, 2005b). The original NHANES question
included categories for annual income greater than $55,000, but due to the population in
which the H.U.B. City Steps intervention targeted, the range was limited to 12 response
choices ranging from less than $5,000 to more than $55,000.

Psychosocial measures. Previously validated psychosocial instruments were
adapted for this study and included social support for physical activity (Russell &
Cutrona, 1984), treatment self-regulation for physical activity and treatment self-
regulation for diet (Levesque et al., 2007), and processes of change for physical activity
(Marcus et al., 1992). The adapted instruments included physical activity social support
from coaches (11 items, three sub-scales: guidance, reliable alliance, reassurance of
worth); physical activity social support from walking group members (12 items, three
sub-scales: guidance, reliable alliance, social integration); treatment self-regulation for
diet and physical activity (15 items each, four sub-scales each: amotivation, external,
introjection, identification and integration); and processes of changes (30 items, 10
subscales: stimulus control, social liberation, reinforcement management, helping
relationships, counter conditioning, self-liberation, self-reevaluation, environmental
reevaluation, dramatic relief, and consciousness raising). Cognitive testing and pre-
testing were conducted on the adapted instrument to ensure that it was appropriate for the
target population. All psychosocial scales were used; the majority (24 of 29) of scales and
subscales demonstrated strong internal consistency with Cronbach’s alpha ≥0.70 when
item composition was maintained from the intended item clustering.

Data Analysis

Descriptive statistics including means, standard deviations, frequencies, and
percents were evaluated in SPSS 18.0 and SEM was performed using Mplus 6.0 with full
Structural equation modeling applies confirmatory factor analysis to variables and was used to examine predictive characteristics in relation to systolic blood pressure. Data analyses took place in the following steps with significance set at the alpha level of 0.05. First, correlation coefficients among the variables were examined. Second, the measurement model was tested to ensure all indicator variables had adequate loadings onto proposed constructs. Lastly, the proposed model was tested structurally and modified according to modification indices that suggested that a correlation between BMI and SES should be added. The modification had theoretical basis and when a chi square difference test was performed, no significant worsening in fit was noted.

**Evaluation of Model Fit**

Based on recommendations by Anderson and Gerbing (1988), a two-step procedure was conducted to test for model fit. First, a confirmatory factor analysis (CFA) was used to test the overall measurement model that consisted of two latent variables and five observed variables (Figure 7). For the latent variables, the loading of the first indicator was set to one in order to create its metric. The measurement model then served as the baseline model for the analysis and comparison of the structural model.

The fit of these models was assessed using the chi-square goodness-of-fit test, which assesses adequacy of the theorized model’s covariance matrix in comparison to the observed covariance matrix. The chi-square test has repeatedly been criticized for its sensitivity to sample size; therefore, inclusion of other fit indices was indicated. The root mean square error of approximation (RMSEA) was used as the absolute fit index while the comparative fit index (CFI) and Tucker-Lewis index (TLI) were used as indices of
incremental fit. A RMSEA has a possible range of 0-1, where a value of about .05 or less suggests a close fit of the model in relation to the degrees of freedom (Browne & Cudek, 1993). It should be noted that a RMSEA value may be misleading when degrees of freedom and sample size are small because while significance may exist, RMSEA values improve as model complexity and sample size increase (Rigdon, 1996). The possible range of the CFI is 0 to 1, where a CFI equal to or greater than .90 is needed to accept the model which would indicate that 90% of the covariation in the data can be reproduced by the given model. The next measure indicating model fit is the TLI where a possible range is also 0-1, and a value close to 1 indicates a good fit. Hu and Bentler (1999) have suggested the TLI should be equal to or greater than .95, and that values below .90 indicate a need to respecify the model.

Results

The sample included mostly African American females (Table 4). A majority were single (58%) and had a college or graduate degree (52.9%). The mode for self-reported health status was “good,” chosen by 48.7% of the sample. A similar number of respondents reported “very good” (20.2%) and “fair” (21.7%) health, whereas only 7.1% reported “excellent” and 2.2% reported “poor” health. Mean SBP at baseline was 125.97 (SD=19.15). Scores for Processes of Change, Social Support and Self-Efficacy are reported at baseline along with means and standard deviations for the observed variables (Table 4).

Measurement Model

The overall model (Figure 7) provided an adequate fit to the data ($X^2=145.339$, degrees of freedom [df]=55, $p<0.001$; $TLI=0.807$; $CFI=0.859$; $RMSEA=0.079$ [CI 90%=
Modification indices indicated a direct effect between BMI and SES as well as marital status and income. It was deemed theoretically appropriate to correlate these terms and the nested measurement model was confirmed. A chi-square difference test was run and the model did not get significantly worse ($\chi^2$ difference=-174.48).

**Structural Model**

The structural model for all participants with standardized coefficients is shown in Figure 8. The model fit well with the data ($\chi^2=81.297$, degrees of freedom [df] = 48, $p=0.002$; TLI=0.917; CFI=0.945; RMSEA=0.051 [CI 90% = 0.031-0.070]). As shown in Table 5 and Figure 8, there were significant relationships between psychosocial and SES latent variables ($p<0.0001$), and for SES with BMI, blood glucose, and self-rated health ($p=0.004$; $p<0.0001$; $p<0.0001$; respectively). The relationship between HDL and SBP approached significance ($p=0.099$). Non-significant paths included all (BMI, HDL, blood glucose, SES, health status, and FFQ) pointing to SBP as well as those for glucose with HDL and BMI, HDL with SES, SES with FFQ, FFQ with health status and psychosocial, and psychosocial to health status.

**Discussion**

Based on a rigorous review of literature, the SEM presented herein attempted to test the impact and interrelationships of variables known to individually affect blood pressure. Results indicate that SES was a significant predictor of two health outcomes and of psychosocial factors within this population. However, none of the paths leading to SBP, the tested health outcome, were significant. Several possibilities for the lack of significant paths could be present, for example, the lack of sensitivity in measures like the
FFQ, which as a dietary assessment method may be less reliable in some ethnic populations (Coates & Monteilh, 1997).

Despite the fact that the psychosocial instruments selected were specific to the diet and physical activity behaviors of interest in this CBPR intervention targeting blood pressure reduction, these psychosocial constructs chosen as predictors of health and possible mediators of behavior change, may not be the appropriate constructs. Previous literature has reported that diet accounted for less than 5% of variance in SBP of African Americans while age accounted for more than 94% and BMI 89% of variance in decreasing SBP of African Americans, respectively (Stanton, Braitman, Riley, Khoo, & Smith, 1982). Nonetheless, as noted previously, the DASH dietary intervention was successful in lowering blood pressure, and therefore other psychosocial mediators of dietary intake or change besides those considered in this study may be more relevant to understanding influences on blood pressure that are amenable to change.

While each of the selected predictors had theoretical reasons based on published literature to be included in the prediction model, possible cultural and geographical differences in the current population as compared to populations in previous studies may have introduced error. Likewise, for the population targeted in this study, recent research suggests that cultural norms, possibly including collectivism and religiosity, might have been important to explore (Kreuter, Lukwago, Bucholtz, Clark & Sanders-Thompson, 2003). In populations experiencing health disparities, social environmental factors, including those encompassed in this study’s variable SES, as well as others including living and working conditions, are increasingly coming to light as predicting health outcomes through a number of mechanisms, including their influences on health behavior
(Robert Wood Johnson Foundation [RWJF], 2011a, 2011b). Furthermore, variables like triglycerides and waist circumference might need to be added to the model to reflect the potential influence of metabolic syndrome, characterized by these biologic measures as well as by blood pressure, HDL cholesterol, and blood glucose already included in the model (Manchia et al., 2010). Metabolic syndrome’s primary clinical outcome is cardiovascular disease which encompasses high blood pressure and atherosclerosis.

Notable findings are the positive significant paths between SES and self-reported health status, and with the health outcomes measures blood glucose and BMI. Hemingway et al. (1997), in the classic Whitehall British civil servants study, found that poorer health functioning as measured by the SF-36 was correlated with lower SES, reflecting in this case constructs of social and occupational class (Moss, 1997). Much literature has been published that addresses disparities in income and education as they relate to health (Boyas, Shobe, & Hannam, 2009; Robinson et al., 2004; Wiltshire, Person, Kiefe, & Allsion, 2009). Research by Yen and Moss (1999) suggested that individuals with higher education may be more likely to partake in health-promoting lifestyles and preventive care, whereas Adler and Newman (2002) suggested that individuals with higher incomes are more likely to have the resources to pay for healthcare and prevention measures, and to afford better nutrition.

These findings are consistent with recent issue briefs on health disparities in the United States, which suggest that factors like chronic stress, living conditions, and asset accumulation reflect socioeconomic conditions that influence health outcomes, and may therefore influence self-perceptions of health (Brandon and Procter, 2010; RWJF, 2011a). The SES measure used in this study did not include a measure of assets or social
environment contextual influences. Assets are known to influence resiliency in the case of an unexpected event requiring resources to be expended while context refers to built environment and geographic regions (Adler & Newman, 2002). Relationships may have been even stronger or significant in other paths if indicators such as these had been included as part of the SES latent variable.

Relationships between SES and FFQ were not significant despite the fact that other studies have found significant relationships between SES and diet. The findings of this study are contrary to the positive associations found in several studies relating SES to Healthy Eating Index scores, Dietary Quality Index scores, and other diet quality measures (Dynesen, Haraldsdottier, Holm, & Astrup, 2003; Mullie, Clarys, Hulens, & Vansant, 2009; Robinson et al., 2004). These studies indicate that higher SES, usually estimated by education level, is associated with better diet quality. However, Coates and Monteilh (1997) found that food frequency questionnaires may be less reliable in ethnic and multiethnic populations than other dietary assessment measures. Perhaps multiple 24-hour recalls, found to be more reliable in African American populations (Coates & Monteilh, 1997), or a culture-specific food frequency questionnaire, such as the one developed in the Mississippi Delta based on the FOODS 2000 survey and adapted for use in the Jackson Heart Study (Carithers et al., 2009), would have been a more accurate/sensitive measure of dietary intake. However, there is a greater respondent burden with use of this quantitative food frequency questionnaire.

As with any analysis there are limitations. First, the data are cross-sectional and therefore limit the ability to make causal inferences. Second, the use of self-reported data limits findings because of known limitations, particularly related to social desirability...
bias. Other issues include the selected SES indicators that comprised the variable SES, as discussed earlier. The intent of the study was to target lower income individuals thus the scale on which incomes were reported was truncated at $55,000; however, almost one-quarter of the sample reported incomes of $55,000 or greater which leaves questions regarding the exact variance of income within this subgroup. Lastly, the findings reported may not be generalizable to other communities with dissimilar characteristics.

Conclusions

The purpose of this research was to test a model of theorized variables that influence blood pressure in a southern, African American population. While the theorized variables were not significantly related to SBP, there were several other relationships of interest. For example, the significant negative relationships between SES and BMI and SES and self reported health status would seem to reinforce the notion that health disparities continue to exist within minority populations of low income and educational attainment.

Additionally, research has repeatedly shown that behaviors ultimately lead to outcomes. Unfortunately, modeling paths that reflect the true influence of characteristics of interest on behavior and in turn on health outcomes is very challenging due to the complexity of health behavior and the cluster of factors that affect health outcomes. Recommendations for more standardized conceptualizations of particular health behaviors and definitions of health outcomes are one of the findings evident in the current discussion.
Figure 7. Structural equation measurement model (Manuscript II). Socioeconomic Status (SES), Food Frequency Questionnaire (FFQ), Body Mass Index (BMI), High density lipoprotein (HDL), Systolic blood pressure (Systolic BP), Education level (Edu), Marital Status (Mar), Processes of change (POC), Social support (SS), Treatment self regulation physical activity (TRSPA), Treatment self regulation diet (TSRD)
Figure 8. Structural Equation Model (Manuscript II). Socioeconomic Status (SES), Food Frequency Questionnaire (FFQ), Body Mass Index (BMI), High density lipoprotein (HDL), Systolic blood pressure (Systolic BP), Education level (Edu), Marital Status (Mar), Processes of change (POC), Social support (SS), Treatment self regulation physical activity (TRSPA), Treatment self regulation diet (TSRD)
Table 4

*Characteristics of Study Sample (Manuscript II)*

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percentage</th>
<th>Range</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
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<tr>
<td>Male</td>
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<tr>
<td>Female</td>
<td>227</td>
<td>85.0%</td>
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<tr>
<td><strong>Age (mean±SD)</strong></td>
<td>267</td>
<td>43.8(12.1)</td>
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<tr>
<td><strong>Race</strong></td>
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<tr>
<td>Black or African American</td>
<td>252</td>
<td>94.4%</td>
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<tr>
<td>White</td>
<td>14</td>
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<td></td>
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<tr>
<td>American India or Alaska native</td>
<td>1</td>
<td>0.4%</td>
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<tr>
<td><strong>Education</strong></td>
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<td></td>
</tr>
<tr>
<td>&lt;11&lt;sup&gt;th&lt;/sup&gt; grade</td>
<td>12</td>
<td>4.5%</td>
<td></td>
<td></td>
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<tr>
<td>12 grade (high school grad/GED)</td>
<td>41</td>
<td>15.2%</td>
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<tr>
<td>Trade or VOC school</td>
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<td>4.8%</td>
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<tr>
<td>Some college</td>
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<td>22.7%</td>
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<td>College degree</td>
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<tr>
<td>Some graduate or professional school</td>
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<td>7.1%</td>
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<td>Graduate level or professional degree</td>
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<td>17.5%</td>
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<td><strong>Total income in the last 12 months</strong></td>
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<td>13.4%</td>
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<td>$20,000-$29,999</td>
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<td>20.1%</td>
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<tr>
<td>$30,000-$39,999</td>
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<td>$40,000-$49,999</td>
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<td>≥$50,000</td>
<td>71</td>
<td>26.4%</td>
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<tr>
<td><strong>Marital status</strong></td>
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</tr>
<tr>
<td>Now married</td>
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<td>42.0%</td>
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<tr>
<td>Widowed</td>
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<td>Divorced</td>
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<tr>
<td>Separated</td>
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<td>3.0%</td>
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<tr>
<td>Never married</td>
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<td>33.1%</td>
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<tr>
<td><strong>Health status</strong></td>
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<tr>
<td>Excellent</td>
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<td>7.1%</td>
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<tr>
<td>Very Good</td>
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<td>20.2%</td>
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<td>Good</td>
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<tr>
<td>Fair</td>
<td>58</td>
<td>21.7%</td>
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<tr>
<td>Poor</td>
<td>6</td>
<td>2.2%</td>
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</tr>
<tr>
<td><strong>BMI</strong></td>
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<td>Normal (18.5-24.9)</td>
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<td>Morbidly obese (≥35)</td>
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<td>42.6%</td>
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Table 4. (continued).

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<td><strong>Psychosocial</strong></td>
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<td>Processes of Change</td>
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<td>50.24</td>
<td>(8.63)</td>
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<td><strong>Self-Reported Health</strong></td>
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<tr>
<td>1=Excellent</td>
<td>2.92</td>
<td></td>
<td></td>
<td>.891</td>
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</tr>
<tr>
<td>5=Poor</td>
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<tr>
<td><strong>Food Frequency Questionnaire</strong></td>
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<td>9.98</td>
<td></td>
<td>2.67</td>
<td></td>
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<tr>
<td><strong>Systolic Blood Pressure</strong></td>
<td>78-180</td>
<td>125.97</td>
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<td>19.21</td>
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Table 5.

Correlation Matrix for Variables in Structural Model (Manuscript II).

<table>
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<tr>
<th></th>
<th>Marital Status</th>
<th>Education Level</th>
<th>Household Income</th>
<th>Systolic Blood Pressure</th>
<th>Food Frequency</th>
<th>Processes of Change</th>
<th>Social Support</th>
<th>Treatment Self-Regulation Physical Activity</th>
<th>Treatment Self-Regulation Diet</th>
<th>Self-Rated Health</th>
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<td>Marital Status</td>
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<td>Education Level</td>
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<td>Household Income</td>
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<tr>
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<tr>
<td>Food Frequency</td>
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<td>0.01</td>
<td>0.02</td>
<td>-0.04</td>
<td>1</td>
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<tr>
<td>Processes of Change</td>
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<td>-0.10</td>
<td>-0.03</td>
<td>0.02</td>
<td>0.11</td>
<td>1</td>
<td></td>
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<tr>
<td>Social Support</td>
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<td>-0.15</td>
<td>-0.09</td>
<td>0.01</td>
<td>-0.13</td>
<td>0.15</td>
<td>1</td>
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<td>-0.21</td>
<td>0.03</td>
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<td>0.39</td>
<td>0.12</td>
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<td>Self-Rated Health</td>
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<td>-0.22</td>
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</tr>
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Burstrom, B., & Fredlund, P. (2001). Self-rated health: Is it as good a predictor of
subsequent mortality among adults in lower as well as in higher social classes? 

*Journal of Epidemiology in Community Health, 55*, 836-840.  

doi:10.1136/jech.55.11.836


http://www.cdc.gov/nchs/data/nhanes/nhanes_05_06/fi_inq_d.pdf


http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5827a2.htm


http://books.nap.edu/openbook.php?record_id=9838


on the prevalence of organ damage, cardiometabolic risk, and cardiovascular events. *Journal of Hypertension, 28*, 999-1006.


industrial nations: Social, psychological and biological pathways (pp.350-351).

CHAPTER VI

CONCLUSIONS

The primary purpose of the present study was to use latent growth modeling (LGM) to determine relationships between latent and observed variables as well as examine factors that not only prompt healthy behavior changes but allow for individual behavior maintenance. The hypothesized model was a complex, mixed model in which observed variables were correlated with latent variables as well as predicted outcomes. Failure of the model to converge, or produce results, resulted in the researcher rejecting the hypothesized model.

Latent variable misspecification is suspected to have prevented the generation of results. However, due to the complex nature not only of the model but also of the factors that lead to abnormal blood pressure, the reason for failure of the model cannot be definitively identified. A more thorough look at the observed variables that comprised the dependent latent variable, health indicator, is warranted.

Secondly, the proposed research attempted to estimate the degree to which several independent variables influence the dependent variable in the context of the H.U.B. City Steps walking intervention by using multiple regression to evaluate the accuracy of prediction of individuals who changed walking behaviors over the six month intervention period. While this proposed attempt at multiple regression was unsuccessful, a SEM was constructed to test theorized properties of what makes an individual’s blood pressure abnormal.

As evidenced by the review of literature, factors that affect blood pressure are many and seem to be lifestyle related. The purpose of the theorized SEM was
identification of interrelationships of factors that are known to be independently
associated with blood pressure. Variables included in the hypothesized model were
demographic (SES), psychosocial (social support, processes of change, self efficacy),
physiologic (BMI, blood glucose, HDL) and health behavior related (food frequency), as
well as perceived health status.

In this study, the model fit indices reflected an acceptable fit of the structural
model, after modifications were made to the measurement model. It is possible that
indicators were incorrect or missing and inclusion of those missing variables would
improve model fit. A closer look at the theorized model and relationships between
specific predictor variables may provide information that will assist in future model
specification in this type of research.

**Summary of Findings**

In the case of the LGM, all corrective actions were exhausted and then the
simplest LGM which was a test of the dependent variable at 0, 3, and 6 months was run.
The LGM did not converge at this simple level despite the fact that some individual
CFA’s were indicative of acceptable fit for each individual dependent variable at time
points independent of one another and of other variables. For example, fit indices for the
CFA of the health indicator dependent variable were good at three months but not at
baseline. Because results could not be generated due to non-convergence of the model,
there is no diagnostic information available to researchers to help inform future analyses.

Some literature suggests that while three time points is the minimum for a LGM
analysis, four to five might actually be better (Fan & Fan, 2005). In addition to a limited
number of repeated measurements included within the LGM, a concern noted by
McArdle and Bell (2000) is that research of developmental trends often shows that early measures tend to have smaller variances than later measures. In essence, individuals become increasingly different as they develop over time which can cause problems when trying to estimate linear growth. These barriers and likely others did not allow for convergence of the LGM presented and similar issues might be appearing frequently without reports being published. Publications of attempts to model health outcomes similar to the ones in this model are rare and discussions of failed attempts are seemingly non-existent; therefore little previous literature is available for reference.

As for the second analysis, the SEM tested revealed that none of the paths leading to SBP were significant. However, paths that were significant included relationships between psychosocial and SES latent variables, and SES with BMI, blood glucose, and self-rated health. In terms of the SEM, while the paths to SBP were not significant, the relationships that existed between SES and the psychosocial latent variable as well as SES and physiologic variables are of interest. A model encompassing an individual’s past health in conjunction with the cultural/social context in which the individual is seated could be used to inform interventions.

**Strengths and Limitations**

As with any analysis there are limitations. While the psychosocial instruments used in this study were previously validated, some changes had to be made to make them more culturally appropriate. Instrumentation used to detect differences must be culturally (i.e. geographic culture), not simply racially, appropriate. Instruments also must be sensitive enough to describe differences while maintaining the focus of the constructs which they are intended to measure. The slight changes made in the instruments used
could have affected their performance despite the fact acceptable Cronbach alphas were found.

Socioeconomic status was measured using education, marital status, and income. The intent of the study was to target lower income individuals thus the scale on which incomes were reported was truncated at $55,000; however, almost one-quarter of the participant sample reported incomes of $55,000 or greater which leaves questions regarding the exact variance of income within this subgroup. Variance within marital status was also limited as were some indicators used in the psychosocial latent variable.

Additionally, the sensitivity of the FFQ, because it was a screener, might be related to the lack of significant paths to things that are generally related in previous literature, for example, FFQ and SES. A concern for future analyses would be to separate the coaches from the participants and run independent analyses or at least take into account the differences that potentially exist between the two groups. Further limitations include the use of self-reported data; even though all surveys were interviewer administered, bias could still be present at this point. Due to the quasi-experimental design of the study, other external factors and events could have been responsible for changes.

All of the predictors had theoretical reasons to be included in the prediction model but due to the cultural and geographical differences seen with the current population as compared to populations the previous studies may have been conducted with, the theory driven concepts may not be relevant. Furthermore, variables like triglycerides and waist circumference might need to be added to the model to indicate the presence of metabolic
syndrome due to the primary clinical outcome being cardiovascular disease which encompasses high blood pressure and atherosclerosis.

Recommendations for Future Research

The purpose of this research was to assess interrelationships of variables known to be independently predictive of blood pressure in a static model and over the course of a six month intervention. This research had thus been intended to highlight that factors predicting blood pressure do not exist alone or even in simple models, as well as that individuals experience different change trajectories in which such complex variables interrelate in differing ways over time. Future research could examine the pathways of individual characteristics that form behaviors and then how the behaviors formed lead to health outcomes. The current LGM assessed individual factors and sought to predict relationships directly to health outcomes but perhaps a more effective analysis might be to use health behaviors as the dependent variable and test health outcomes independently.

Future research could also utilize hierarchical linear modeling (HLM), which is a technique that describes individuals in the context of an environment. In the current study, for example, participants could be nested in walking groups and then into communities. Multiple time points can also be assessed using this design but in contrast to LGM, time-series data is treated as a level so the number of time points available for analysis may not present the same issues as with LGM.

Additionally, as mentioned before, relatively few articles have been published within health behavior, specifically nutrition and physical activity literature, using LGM techniques as the primary form of data analysis. While a few examples include testing measurement invariance (Nigg, Lippke, & Maddock, 2009; Paxton et al., 2008),
mediation and moderation (Dutton, Napolitano, Whiteley, & Marcus, 2007; Roesch, Norman, Villodas, Sallis, & Patrick, 2010; Schwarzer et al., 2007), and process evaluation (Hess, 2000), information about defining characteristics that comprise health behaviors and inconclusive or rejected models are rare. Future researchers could benefit from a more standardized approach to modeling health behaviors so that literature can be compared and built upon. Current published findings do not seem to be comparable across studies and therefore limit more generalized conclusions.

While the primary analysis was unsuccessful, the research described herein is quite valuable. Future researchers need guidance as to how to approach conceptualizing and testing latent variables that are related to health behaviors and outcomes. Furthermore, approaches where successful as well as unsuccessful modeling attempts are discussed and appreciated should be promoted and reported.
APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

THE UNIVERSITY OF SOUTHERN MISSISSIPPI
Institutional Review Board
118 College Drive #5147
Hattiesburg, MS 33406-9001
Tel: 601.266.6290
Fax: 601.266.5599
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by the University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 21, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.
- Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: C28032601
PROJECT TITLE: A Community Partnership to Reduce Blood Pressure
PROPOSED PROJECT DATES: 10/26/2010 to 09/30/2011
PROJECT TYPE: Previously Approved Project
PRINCIPAL INVESTIGATORS: Kathy Yadrick, Ph.D.
COLLEGE/DIVISION: College of Health
DEPARTMENT: Nutrition and Food Systems
FUNDING AGENCY: National Institutes of Health — Grant # R03307
HSPRC COMMITTEE ACTION: Expected Review Approval
PERIOD OF APPROVAL: 10/26/2010 to 09/29/2011

[Signature]
Lawrence A. Hosman, Ph.D.
HSPRC Chair

10-26-2010
Date
APPENDIX B

DATA COLLECTION FORMS

Demographics (DEM) Data Collection Form

[READ ALOUD EACH QUESTION AND ITS RESPONSE CHOICES TO PARTICIPANT AND FILL IN THE APPROPRIATE LETTER OR NUMBER AFTER THE PARTICIPANT RESPONDS]

[READ TO PARTICIPANT]: “Now, I am going to ask you some questions about yourself…”

|___| DEM01. [DO NOT ASK] Record the participant’s sex.
  [1] Male
  [2] Female

|___| DEM02. Do you consider yourself to be Hispanic or Latino?
A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
  [1] Yes, Hispanic or Latino
  [2] Not Hispanic

|___|, |___| DEM03. What race do you consider yourself to be? Select one or more of the following.
  [1] American Indian or Alaska Native
  [2] Asian
  [3] Black or African American
  [4] Native Hawaiian or Other Pacific Islander
  [6] More than two of the above
  [98] Don’t Know
  [99] Refused

[SHOW MARITAL STATUS HAND CARD]

|___| DEM04. What is your marital status?
  [1] Now Married
  [3] Divorced
[SHOW LEVEL OF SCHOOL COMPLETED HAND CARD]

DEM05. What was the last level of school you have completed:

[ ] [1] < 6th Grade
[ ] [2] 6th thru 9th Grade
[ ] [3] 10th thru 11th Grade
[ ] [4] 12th Grade (High School Grad/ GED)
[ ] [5] Trade or VOC School
[ ] [6] Some College
[ ] [7] College Degree
[ ] [8] Some Graduate or Professional School
[ ] [9] Graduate Level or Professional Degree
[ ] [98] Don’t Know
[ ] [99] Refused

[SHOW NUTRITION AND PHYSICAL ACTIVITY PROGRAM HAND CARD]

DEM06. Are you participating in any of the following nutrition programs right now?

[CHECK ALL THAT APPLY].

[ ] [1] Food Stamps or the Supplemental Nutrition Assistance Program (SNAP) or EBT
[ ] [2] The Food Stamp Nutrition Education (FSNE) Program (education program for Food Stamp recipients) or Supplemental Nutrition Assistance Program Education (SNAP-Ed)
[ ] [3] The Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)
[ ] [4] Others, please give name______________________________
[ ] [5] None of these
DEM07. Please tell me about any physical activity or exercise programs you are participating in right now. This includes if you are currently a member to a gym

[CHECK ALL THAT APPLY].

[ ] [1] Gym membership, please specify__________________________________________
[ ] [2] Others, please give name__________________________________________
[ ] [3] Not participating in any physical activity or exercise programs right now

[ ] DEM08. Are any other members of your household participating in the Healthy U Begins with Steps (H.U. B City Steps) program?

[1] Yes
[2] No

[SHOW HEALTH STATUS HAND CARD]

[ ] DEM09. In general, would you say that your health is:

[1] Excellent
[2] Very good
[3] Good
[4] Fair
[5] Poor
[READ TO PARTICIPANT]: “Now I would like to ask you about your total household income. No one in the community or any agency will see your answers to these questions.”

[SHOW INCOME HAND CARD]

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>DEM10. Of these income groups, can you tell me which number best represents your household’s total income in the last 12 months?</th>
</tr>
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<tr>
<td>1</td>
<td></td>
<td>Less than $5,000</td>
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<td>2</td>
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<td>$5,000-9,999</td>
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<td>$10,000-14,999</td>
</tr>
<tr>
<td>4</td>
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<td>12</td>
<td></td>
<td>More than $55,000</td>
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<tr>
<td>[98]</td>
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<td>Don’t Know</td>
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<tr>
<td>[99]</td>
<td></td>
<td>Refused</td>
</tr>
</tbody>
</table>
Food Frequency Questionnaire (FFQ) Data Collection Form

[READ TO RESPONDENT]: “For the next five questions please think about the different kinds of food you ate or drank during the PAST MONTH, that is, the past 30 days. When answering, please include meals and snacks eaten at home, at work or school, in restaurants, and anyplace else.”

[SHOW FOOD FREQUENCY HAND CARD]

[___] | [___] FFQ01. During the past month, how often did you eat HOT OR COLD CEREALS?

[1] Never (Skip to FFQ03)
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused (Skip to FFQ03)
[99] Don’t know (Skip to FFQ03)

[___] , [___] FFQ02. When you ate cereal, which kinds did you usually eat?

* Enter one or two types. Separate with a comma.

[1] Cooked cereals (such as oatmeal, cream of wheat, grits)
[2] All bran cereals (such as All Bran, Fiber one, 100% Bran, or Bran Buds)
[3] Cereals with some bran or fiber (such as Cheerios, Raisin Bran, Shredded Wheat, Total, Wheaties, 40% Bran flakes, Granola, Grape Nuts, Muselix, etc.)
[4] Cereals with little bran or fiber (such as Corn Flakes, Honey Nut Cheerios, Fruit Loops, Rice Krispies, Kix, Frosted Flakes, Special K, Cap’n Crunch, Blueberry Morning, Product 19, etc.)
[5] Other
[98] Refused
[99] Don’t know
FFQ03. How often did you have MILK, either to drink or on cereal? Do NOT include small amounts of milk in coffee or tea.

*Read if necessary: Do NOT include cream or soymilk. INCLUDE skim, no fat, low fat, whole milk, buttermilk, and lactose-free milk. Also INCLUDE chocolate or other flavored milks.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know

FFQ04. During the past month, how often did you drink regular, carbonated SODA OR SOFT DRINKS that contain sugar? Do NOT include diet soda.

*Read if necessary: Do NOT include diet or sugar-free fruit drinks. Do NOT include juices or tea in cans. Do NOT include diet mineral water or diet flavored waters.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know
FFQ05. During the past month, how often did you drink 100% FRUIT JUICE, such as orange, mango, apple, and grape juices? Do NOT count fruit drinks.

*Read if necessary: INCLUDE only 100% pure juices. Do NOT include fruit drinks with added sugar, like Kool-aid, Hi-C, lemonade, cranberry cocktail, Gatorade, Tampico, and Sunny Delight.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know

FFQ06. NOW we are going to ask about FRUIT-FLAVORED drinks WITH ADDED SUGAR.

How often did you drink FRUIT-FLAVORED DRINKS with sugar (such as Kool-aid, Hi-C, lemonade, or cranberry cocktail, Gatorade, Tampico, and Sunny Delight)? Do NOT include diet drinks.

*Read if necessary: INCLUDE Gatorade and other sports drinks with added sugar. INCLUDE Tampico, Sunny Delight and Twister. Do NOT include 100% fruit juices or soda. Do NOT include yogurt drinks or carbonated water.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know
|   |   | FFQ07. How often did you eat FRUIT? COUNT fresh, frozen, or canned fruit. Do NOT count juices.

*Read if necessary: Include fruits such as apples, bananas, applesauce, melon, berries, fruit salad, mangos, papayas, oranges, and grapes.

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<tbody>
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<td>1</td>
<td>Never</td>
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<tr>
<td>2</td>
<td>1-3 times last month</td>
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<tr>
<td>3</td>
<td>1-2 times per week</td>
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<td>10</td>
<td>5 or more times per day</td>
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<td>98</td>
<td>Refused</td>
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<tr>
<td>99</td>
<td>Don’t know</td>
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</table>

|   |   | FFQ08. During the past month, how often did you eat a green leafy or lettuce SALAD, with or without other vegetables? INCLUDE spinach salads.

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<td>Never</td>
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<tr>
<td>2</td>
<td>1-3 times last month</td>
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<td>3</td>
<td>1-2 times per week</td>
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<tr>
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<td>5 or more times per day</td>
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<tr>
<td>98</td>
<td>Refused</td>
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<tr>
<td>99</td>
<td>Don’t know</td>
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### FFQ09. How often did you eat FRENCH FRIES, home fries, or hash brown potatoes?

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<td>Never</td>
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<td>5 or more times per day</td>
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<tr>
<td>98</td>
<td>Refused</td>
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<td>99</td>
<td>Don’t know</td>
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### FFQ10. How often did you eat other WHITE POTATOES? COUNT baked potatoes, boiled potatoes, mashed potatoes and potato salad.

*Read if necessary: Do NOT include yams or sweet potatoes. INCLUDE red-skinned and Yukon Gold potatoes.*

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<td>1</td>
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<td>2</td>
<td>1-3 times last month</td>
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<td>3</td>
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<td>Refused</td>
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FFQ 11. How often did you eat COOKED DRIED BEANS, such as refried beans, baked beans, bean soup, pork and beans, black-eyed peas, red beans, lima beans, and black beans? Do NOT include green beans.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know

FFQ 12. Not counting what you just told me about (lettuce salads, white potatoes, cooked dried beans), and not counting rice, how often did you eat OTHER VEGETABLES?

*Read if necessary: Examples of other vegetables include tomatoes, string beans, carrots, corn, sweet potatoes, cabbage, bean sprouts, collard greens, and broccoli.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know
FFQ 13. How often did you have TOMATO SAUCES such as spaghetti sauce or pizza with tomato sauce?

1. Never
2. 1-3 times last month
3. 1-2 times per week
4. 3-4 times per week
5. 5-6 times per week
6. 1 time per day
7. 2 times per day
8. 3 times per day
9. 4 times per day
10. 5 or more times per day
98. Refused
99. Don’t know

FFQ 14. How often did you have SALSA?

1. Never
2. 1-3 times last month
3. 1-2 times per week
4. 3-4 times per week
5. 5-6 times per week
6. 1 time per day
7. 2 times per day
8. 3 times per day
9. 4 times per day
10. 5 or more times per day
98. Refused
99. Don’t know
FFQ15. How often did you eat RED MEAT?

*Read if necessary: Red meat refers to meat that appears red before cooking. Beef, veal, lamb, mutton, venison, pork, goat, rabbit, and buffalo meat are all red meats.

[1] Never  
[2] 1-3 times last month  
[3] 1-2 times per week  
[4] 3-4 times per week  
[5] 5-6 times per week  
[6] 1 time per day  
[7] 2 times per day  
[8] 3 times per day  
[9] 4 times per day  
[10] 5 or more times per day  
[98] Refused  
[99] Don’t know

FFQ16. How often did you eat WHOLE GRAIN BREAD including toast, rolls, and in sandwiches? Whole grain breads include whole wheat, rye, oatmeal and pumpernickel. Do NOT include white bread.

*Read if necessary: INCLUDE cracked wheat, multi-grain, and bran breads.

[1] Never  
[2] 1-3 times last month  
[3] 1-2 times per week  
[4] 3-4 times per week  
[5] 5-6 times per week  
[6] 1 time per day  
[7] 2 times per day  
[8] 3 times per day  
[9] 4 times per day  
[10] 5 or more times per day  
[98] Refused  
[99] Don’t know
FFQ17. During the past month, how often did you eat DOUGHNUTS, sweet rolls, Danish, muffins, or pop-tarts? Do NOT include sugar-free items. INCLUDE low fat kinds.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know

FFQ18. How often did you eat COOKIES, CAKE, PIE, or BROWNIES? Do NOT include sugar-free kinds.

*Read if necessary: INCLUDE low fat kinds. Do NOT include ice cream or other frozen desserts or candy.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know
FFQ19. How often did you eat any kind of CHEESE? Include cheese as a snack, cheese on burgers, sandwiches, or pizza, and cheese mixed into such foods as lasagna, enchiladas or casseroles. Do NOT count cream cheese.

[1] Never
[2] 1-3 times last month
[3] 1-2 times per week
[4] 3-4 times per week
[5] 5-6 times per week
[6] 1 time per day
[7] 2 times per day
[8] 3 times per day
[9] 4 times per day
[10] 5 or more times per day
[98] Refused
[99] Don’t know

FFQ 20. During the PAST 12 MONTHS, did you take any vitamin or mineral supplements of ANY KIND?

*Read if necessary: INCLUDE vitamin or mineral pills, liquids, or tinctures. Do NOT include vitamin-fortified foods.

[1] Yes
[2] No
[98] Refused
[99] Don’t know

[STATION 1 END TIME]: [___|___] : [___|___] AM PM [Circle AM or PM]
Blood Pressure (BP) Data Collection Form

[PARTICIPANT ID Number]: |___|___|___|___|___|___|___|

[DATA COLLECTOR ID Number]: |___|___|___|___|___|___|___|

[STATION 2 START TIME]: [Circle AM or PM]

BP01. Arm Circumference

___|___|___| centimeters
[Enter centimeters]

BP02. Cuff Size

S    M    L    XL
[Circle one]

BP03. Blood Pressure

___|___|___| systolic
[Enter systolic blood pressure]

___|___|___| diastolic
[Enter diastolic blood pressure]

[IF SECOND READING IS NEEDED]

___|___|___| systolic
[Enter systolic blood pressure]

___|___|___| diastolic
[Enter diastolic blood pressure]
Anthropometric and Body Composition (ABC) Data Collection Form

[PARTICIPANT ID Number]: |___||___||___||___||___||___|

[DATA COLLECTOR ID Number]: |___||___||___||___||___||___|

ABC01. Height

|___||___||___| centimeters

[Enter number of centimeters]

ABC02. Waist Circumference

|___|___|___| centimeters

[Enter number of centimeters]

*Does the participant have a pacemaker |___|

[Enter Y or N]

(Y) Yes
(N) No

[IF YES THAN WEIGH ON A BALANCE BEAM SCALE AND DO NOT PERFORM TANITA]

ABC03. Weight

|___|___|___|.|___| Kilograms

[Enter number of kilograms]

*If female, ask if pregnant? |___|

[Enter Y or N]

(Y) Yes
(N) No

[IF YES THAN WEIGH ON A BALANCE BEAM SCALE AND DO NOT PERFORM TANITA]

If yes, what was her weight before pregnancy:

|___|___|___|.|___| Pounds

[Enter number of pounds]

|___| Don’t know
ABC04. Body Mass Index (BMI) |___|___|.|___|
[Enter BMI]

ABC05. Impedance |___|___|___|
[Enter impedance]

ABC06. Percent (%) Body Fat |___|___|.|___|%
[Enter percent]

ABC07. Fat Mass (kg) |___|___|.|___| kilograms
[Enter kilograms]

ABC08. Lean Body Mass (LBM-kg) |___|___|.|___| kilograms
[Enter kilograms]

ABC09. Total Body Water (TBW-kg) |___|___|.|___| kilograms
[Enter kilograms]
Blood Measures (BL) Data Collection Form

[PARTICIPANT ID Number]: |___||___||___||___||___||___|

[DATA COLLECTOR ID Number]: |___||___||___||___||___||___|

BL01. Total Cholesterol  |_______| mg/dl
[Enter Total Cholesterol reading]

BL02. HDL  |_______| mg/dl
[Enter HDL reading]

BL03. Triglycerides  |_______| mg/dl
[Enter triglyceride reading]

BL04. LDL  |_______| mg/dl
[Enter LDL reading]

BL05. Glucose  |_______| mg/dl
[Enter glucose reading]

[STATION 2 END TIME]: |___|:|___| AM   PM
[Circle AM or PM]
Treatment Self-Regulation Physical Activity (TSPA) Data Collection Form

[PARTICIPANT ID Number]: |___||___||___||___||___||___|

[READ TO PARTICIPANT]: “The following statements relate to reasons why you would either start to exercise regularly or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you.

Please indicate the extent to which each reason is true for you, using the following 5-point scale:”

[SHOW SELF-REGULATION HAND CARD]

[1] Not at all true of me
[2] Somewhat untrue of me
[3] Neutral (neither true or untrue of me)
[4] Somewhat true of me
[5] Very true of me

[READ TO PARTICIPANT]: “Some of the statements may be hard to answer, so if you do not have an opinion either way you can answer ‘neutral’. The goal is to allow a clear and personalized expression of feelings. Remember, if you do not have an opinion either way you can answer ‘neutral’.”

The reason I would exercise regularly is:

|___| TSPA01. Because I feel that I want to take responsibility for my own health.
|___| TSPA02. Because I would feel guilty or ashamed of myself if I did not exercise regularly.
|___| TSPA03. Because I personally believe it is the best thing for my health.
|___| TSPA04. Because others would be upset with me if I did not exercise.
|___| TSPA05. I really don't think about it.
|___| TSPA06. Because I have carefully thought about it and believe it is very important for many aspects of my life.
|___| TSPA07. Because I would feel bad about myself if I did not exercise regularly.
Because it is an important choice I really want to make.

Because I feel pressure from others to do so.

Because it is easier to do what I am told than think about it.

Because it is consistent with my life goals.

Because I want others to approve of me.

Because it is very important for being as healthy as possible.

Because I want others to see I can do it.

I don't really know why.

Treatment Self-Regulation Diet (TSD) Data Collection Form

[READ TO RESPONDENT]: “The following statements relate to the reasons why you would either start eating a healthier diet or continue to do so. Different people have different reasons for doing that, and we want to know how true each of the following reasons is for you.

Please indicate the extent to which each reason is true for you, using the following 5-point scale:”

[SHOW SELF-REGULATION HAND CARD]

[1] Not at all true of me
[2] Somewhat untrue of me
[3] Neutral (neither true or untrue of me)
[4] Somewhat true of me
[5] Very true of me

[READ TO PARTICIPANT]: “Some of the statements may be hard to answer, so if you do not have an opinion either way you can answer ‘neutral’. The goal is to allow a clear and personalized expression of feelings. Remember, if you do not have an opinion either way you can answer ‘neutral’.”

The reason I would eat a healthy diet is:

Because I feel that I want to take responsibility for my own health.

Because I would feel guilty or ashamed of myself if I did not eat a healthy diet.
| TSD03. | Because I personally believe it is the best thing for my health. |
| TSD04. | Because others would be upset with me if I did not have a healthy diet. |
| TSD05. | I really don't think about it. |
| TSD06. | Because I have carefully thought about it and believe it is very important for many aspects of my life. |
| TSD07. | Because I would feel bad about myself if I did not eat a healthy diet. |
| TSD08. | Because it is an important choice I really want to make. |
| TSD09. | Because I feel pressure from others to do so. |
| TSD10. | Because it is easier to do what I am told than think about it. |
| TSD11. | Because it is consistent with my life goals. |
| TSD12. | Because I want others to approve of me. |
| TSD13. | Because it is very important for being as healthy as possible. |
| TSD14. | Because I want others to see I can do it. |
| TSD15. | I don't really know why. |
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