Neighborhood design and body mass: Does weight status differ between a new urbanist and conventional suburban neighborhoods?

by

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Neighborhood design and body mass: Does weight status differ between a new urbanist and conventional suburban neighborhoods?

Abstract

Background: The increasing prevalence of overweight and obesity is a public health concern in the United States. There is a small but growing body of literature examining the relationship between neighborhood level characteristics, physical activity and weight status. However, to date, none of these studies have examined the association between new urbanist communities and weight status.

Objective: To examine the prevalence of overweight, obesity and body mass index of household heads in a new urbanist neighborhood relative to household heads of comparable conventional suburban neighborhoods.

Method: Using a quasi-experimental design, a new urbanist neighborhood and five conventional suburban neighborhoods in central North Carolina were matched on age of development, assessed property values and regional accessibility. Self-reported height, weight, physical activity and travel behaviors were derived through a questionnaire and travel diary mailed to the heads of household in each neighborhood type between March and May 2003.

Results: No significant difference was detected in BMI, overweight and obese prevalence, or moderate and vigorous physical activity levels between household heads in the new urbanist neighborhood and the conventional suburban neighborhoods after controlling for socio-demographic characteristics. However, the study found that new urbanist heads of household made more in-neighborhood utilitarian trips by walking or bicycling than their conventional suburban counterparts and these physical activity trips were related to lower BMI.

Conclusion: By offering an environment supportive of non-motorized travel and mixed land uses, household heads of the new urbanist neighborhood integrated walking and biking into their utilitarian trip making. The utilitarian physical activity trips were associated with a lower BMI, however, yet residing in the new urbanist neighborhood was not related to lowering BMI or decreased likelihood of being overweight and obese.
1. Introduction

A major public health issue currently facing the United States is the continued increase in the number of obese and overweight adults. From 1990 to 2002, the percentage of obese adults grew nationally from 11.6% to 22.1% and the percentage of overweight adults climbed from 33.1% to 37.4% (National Center for Chronic Disease Prevention and Health Promotion). More than half of adults in the U.S. are either overweight or obese. This trend is alarming, given the negative health consequences of overweight and obesity, including premature death and disability, increased health care costs, lost productivity and social stigmatization (U.S. Department of Health and Human Services, 2001). In addition, overweight and obesity are risk factors for a host of chronic diseases, including cardiovascular disease, Type 2 diabetes, hypertension, various cancer types (endometrial, kidney, colon and postmenopausal breast), sleep apnea and osteoarthritis (Felson, 1988; Pi-Sunyer, 1999; U.S. Department of Health and Human Services, 2001).

During the past decade, the economic costs resulting from treating diseases related to overweight and obesity were astounding. In 1998, medical expenditures directly resulting from overweight and obesity accounted for 9.1%, or $78.5 billion, of total U.S. medical expenditures, of which Medicare and Medicaid financed approximately half of these costs (Finkelstein, Fiebelkorn, & Wang, 2003). When indirect costs of losses in productivity and wages attributable to obesity are combined with the direct medical costs, the expenditures approach $117 billion annually (Wolf, 1998). Obese adults, on average, incur annual medical expenditures ranging from $395 to $450 higher than adults of normal weight (Sturm, 2002; Wang, McDonald, Champagne, & Edington, 2004). Since these health and economic impacts are largely preventable, it is important to focus on the causes of and methods to reverse this trend.

A person’s propensity to be overweight or obese is determined by a combination of genetic, behavioral, environmental, cultural, and socio-economic factors (U.S. Department of Health and Human Services, 2001). There is a growing body of literature documenting the connections between body weight, lifestyle (U.S. Department of Health and Human Services, 2001) and levels of physical activity and inactivity (Jakicic, 2002; McGuire, Wing, Klem, & Hill, 1999; Sharpe, Granner, Hutto, Ainsworth, & Cook, 2004). Numerous individual-focused efforts have been undertaken with the goal of improving health by increasing physical activity and decreasing inactivity, but few have achieved long-term physical activity levels that are sustainable and sufficient to prevent the onset and exacerbation of excess and unhealthy weight gain (Hillsdon, Foster, & Thorogood, 2005). When used as the sole intervention type, individual-based approaches are widely viewed as ineffective because they fail to change the environmental factors contributing to population-wide overeating and inadequate physical activity (McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis & Owen, 2002).

Recognizing the shortcomings of individual-level interventions, increased attention has been given to multi-level frameworks such as the social ecological model (Stokols, 1992) and the social determinants of health and environmental health promotion model (Northridge, Sclar, &
Biswas, 2003). These models consider that the factors influencing behavior come from multiple levels (i.e. intrapersonal, interpersonal, organizational/institutional, community, and public policy). An ecological perspective is critical for focusing attention on the multiple environmental causes of behavior and identification of corresponding environmental interventions that may support behavior change and bring about population improvements in health (McLeroy et al., 1988; Sallis & Owen, 2002).

The majority of evidence from previous studies comparing the built environment characteristics of traditionally designed neighborhoods with more conventionally designed suburban-type neighborhoods suggest that residents in the traditionally designed developments should be more physically active than residents in the conventionally designed developments (L.D. Frank & Engelke, 2001; Saelens, Sallis, & Frank, 2003). Because many design characteristics that typify a traditional neighborhood are emulated in new urbanist neighborhoods, similar differences in physical activity are expected to occur between residents of new urbanist neighborhoods and residents of conventional suburban neighborhoods.

Therefore, this paper examines the hypotheses that individuals living in a new urbanist neighborhood make more trips via non-motorized modes (walking and biking), obtain more physical activity, have a lower BMI and be less likely to be overweight and obese than residents living in a conventional suburban neighborhood.

The data analyzed in this paper were collected using questions adopted from transportation planning and public health surveillance. Particular travel information was obtained using a travel diary modified from the 2001 National Household Transportation Survey, the primary source of data on nationwide travel behavior (U.S. Department of Transportation, 2003). Questions on moderate and vigorous physical activity were from the 2001 Behavioral Risk Factor Surveillance System (BRFSS) survey (National Center for Chronic Disease Prevention and Health Promotion, 2004). Using questions commonly asked by each discipline facilitates comparability between existing and future studies.

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1 Traditional neighborhoods had characteristics of higher residential density, greater street connectivity, and more diversity of land uses within or in close proximity to the neighborhood. Conventional neighborhoods were characterized by low residential density, poorly connected streets, and single-land use (residential) within the neighborhood.

2 In general, new urbanist developments, also known as neo-traditional developments, are designed at a human-scale to accommodate pedestrians, transit and the automobile (Congress of New Urbanism, 2005). They provide an environment characterized by sidewalks flanking both sides of the streets, which are arranged in a grid-like pattern to allow for good connectivity with short block length, few cul-de-sacs, and slow vehicular speeds. These new urbanist developments: offer a variety of residential dwelling types (single–family, apartments, townhouses and condominiums) that are situated close to the street within their lot; have a diversity of land use types including schools, stores, offices, and parks; have a discernible neighborhood center located within a five-minute walk (1/4 mile) of most residential dwellings; and are serviced by transit (Victoria Transport Policy Institute, 2005).

Conversely, most conventional suburban developments in the U.S. are typified by: low-density detached single–family residential housing (3-4 dwelling units per acre or less), which are set back from the street; environments with low walkability, defined as low street connectivity, a high portion of cul-de-sacs, long block lengths and curvilinear street patterns; and the lack of a distinct activity center (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2003; Saelens, Sallis, Black, & Chen, 2003). They are designed to be automobile-oriented, making the car the primary – if not only – mode of travel and they may inhibit or impede physical activity since shops, workplaces, parks and green spaces are not within convenient, reasonable or safe walking distances (Handy, Boarnet, Ewing, & Killingsworth, 2002; Sallis, Johnson, Calfas, Caparosa, & Nichols, 1997).
This paper responds to calls for more studies on the effects of neighborhood design on physical activity and weight by comparing the weight status and physical activity levels of residents living in a large new urbanist neighborhood with residents from a conventional suburban neighborhood (A. J. Khattak & Rodriguez, In press; Saelens, Sallis, Black et al., 2003). More specifically this paper hypothesizes the following:

- **Primary hypotheses:**
  - Residents living in new urbanist neighborhoods have a lower BMI than residents in the conventional suburban.
  - Residents living in new urbanist neighborhoods are less likely to be overweight or obese than residents in the conventional suburban neighborhood.

- **Secondary hypotheses:**
  - Residents living in new urbanist neighborhoods make more trips via non-motorized modes (walking and biking) than residents in the conventional suburban neighborhood.
  - Residents living in new urbanist neighborhoods obtain more physical activity than residents in the conventional suburban neighborhood.

**Ecological Model**
The ecological model presented in Figure 1, although not comprehensive, shows some of the known and suggested constructs that influence people’s health. In the model, the arrows of the lines indicate the directional flow of influence between the constructs. Overall, this model posits that the neighborhood environment has an influence on trip and mode choice, which in turn influences the type and location of physical activity, and being physically active has an impact on health. Additionally, the environment of the neighborhood has a direct association with physical activity. This study specifically focuses on variables related to various attributes of the built environment at the neighborhood level, motorized and non-motorized trip making, levels of physical activity and body weight while controlling for select socio-demographic characteristics.

The model indicates that the neighborhood environment can influence trip and mode choice. For instance, increasing mixed use development, population density and sidewalks are associated with increased proportion of trips made by non-motorized means (Cervero & Kockelman, 1997; L. Frank & Pivo, 1995; D. Rodriguez & Joo, 2004). The decision to travel by a particular mode influences how and where a person obtains physical activity (D. A. Rodriguez, Khattak, & Evenson, In press). Trips made by foot and bike contributes to a person’s overall physical activity level.

To the right hand of the model, the relationship between physical activity and health is well established. Existing evidence finds significant associations between levels of physical activity and risks for certain cancers, cardiovascular disease and weight, (U.S. Department of Health and Human Services, 1996) (Jakicic, 2002; Sharpe et al., 2004). Each of these factors is influenced by a person’s individual characteristics (McNally & Kulkarni, 1997; Robert & Reither, 2004; Trost, Owen, Bauman, Sallis, & Brown, 2002).
2. Literature Review

There is a significant and growing body of literature examining the relationship between the built environment and physical activity. For example, a report jointly prepared by the Transportation Research Board and Institutes of Medicine of The National Academies (Committee on Physical Activity, 2005) contains a thorough review of studies from the areas of urban planning, travel behavior, public health and physical activity. Among other things, the report found that the relationship between the built environment is complex and operates through numerous factors and that the built environment can facilitate or constrain physical activity. However, the majority of available empirical evidence can only show an association between the built environment and physical activity, but is not capable of demonstrating a causal relationship due to the cross-sectional study design of the studies (Committee on Physical Activity, 2005). Most of the literature has focused on the environmental determinants of physical activity at the neighborhood level (Committee on Physical Activity, 2005). These determinants include street characteristics, presences of sidewalks, aesthetics, and convenient access to shops and stores are related primarily to physical activity within the neighborhood (Committee on Physical Activity,
2005). Arguably, the impetus for examining the relationship between the built environment and physical activity is ultimately aimed at understanding how to improve people’s health outcomes, including healthy weight status. However, to date, a paucity of studies have included measures related to participants’ weight and physical activity when examining the built environment, and even fewer have narrowed their focus to residents of new urbanist neighborhoods.

Recent work has found a higher prevalence of obesity and overweight in areas where segregated land use makes walking to destinations difficult (Ewing et al., 2003) (L.D. Frank, Andresen, & Schmid, 2004; Saelens, Sallis, Black et al., 2003). A study by Ewing and colleagues (2003) relating development patterns (e.g. location of homes, shops and workplaces relative to one another; street connectivity and urban block size) to various health outcomes used data aggregated at the county and metropolitan levels. The researchers constructed sprawl indices to measure the built environment in 448 counties and 83 metropolitan areas across the United States. They found that after controlling for demographic and behavioral covariates, the built environment had small but significant associations with minutes walked, hypertension, heart disease, obesity and body mass index (BMI) at the county level. People in more compact counties, as indicated by the sprawl index, had a lower BMI than the residents of more sprawling counties. The metropolitan level analysis found only the variable “minutes walked” to be significantly related to the built environment. While they found a statistically significant difference in BMI between the residents of more and less compact counties, the magnitude of the BMI coefficient (-0.003, \( p = 0.005 \)) suggest only a very small meaningful difference. In the study, the geographic scale of analysis was a limitation because the county and metropolitan levels allowed for only a macro-view of the built environment, not a community or neighborhood view, which can vary dramatically between locations in relatively close proximity. This limitation is important since physical activity such as walking is influenced more by neighborhood level characteristics and less by the structure of the region. (Ball, Bauman, Leslie, & Owen, 2001; Greenwald & Boarnet, 2002; King et al., 2000; D. A. Rodriguez et al., In press). Thus, a need exists to continue researching the relationship between BMI and neighborhood characteristics.

To help address this limitation of geographic scale, Frank (2004) and colleagues examined the areas within a one-kilometer buffer around the residences of study participants in the Atlanta region. After assessing the relationship between the built environment, travel patterns and obesity, the researchers found that the likelihood of being obese significantly declined as the diversity of land use grew increasingly mixed and walking distance increased. Conversely, the odds of being obese increased by 6% for each hour spent traveling by automobile. Furthermore, a second study found that the built environment, as measured by land use mix, street connectivity and residential density within a one-kilometer road network-based buffer around each participant’s place of residence, was positively associated with objectively measured moderate levels of physical activity in adults (L. D. Frank, Schmid, Sallis, Chapman, & Saelens, 2005).

Unlike the Frank (2004) study, where the participants were dispersed throughout a large region, work by Saelens et al. (2003) narrowed the focus to neighborhoods and the adults residing within them. Saelens and colleagues significant differences in objectively measured physical activity and overweight prevalence between adults living in two neighborhoods with distinctly different land use types, residential density and street layout (Saelens, Sallis, Black et al., 2003). The
highly walkable neighborhood, characterized by greater street connectivity, higher concentration of nonresidential land uses and residential density, had residents that engaged in approximately 52 minutes more of moderate-intensity physical activity during the week and a lower prevalence of overweight (35.2% vs. 60.4%) than residents in the neighborhood with low walkability. The authors reported that their findings lend preliminary support to the hypothesis that macro-environmental factors and neighborhood design trends were contributing to the overweight and obesity issue.

Another study concentrating on two defined neighborhood types was conducted by Rodriguez and colleagues (In press). They compared physical activity levels of residents from new urbanist and five conventional suburban neighborhoods. The overall levels of physical activity did not differ significantly between the two neighborhood types. The study found that new urbanist household heads compared to household heads of the conventional suburban developments made a similar number of walking trips for recreational purposes, but engaged in more walking for utilitarian purposes. The findings suggest that while new urbanist neighborhoods were not related to higher levels of physical activity, the new urbanist residents incorporated walking and bicycling into their trips when accessing destinations within the neighborhood.

A further analysis by Khattak and Rodriguez (In press) of the new urbanist and conventional suburban neighborhoods data focused on the associations of neighborhood design on travel behavior. After controlling for demographics and accounting for self-selection, they found that members of single-family households in the new urbanist neighborhood made a similar number of total trips as their counterparts in the conventional suburban neighborhood. However, the new urbanist residents compared to residents of the conventional suburban neighborhoods made fewer automobile trips and took more transit trips and made more walking trips, with many of these walking trips occurring inside the neighborhood. These findings suggest that households in the new urbanist neighborhood substitute driving trips with walking trips. Several attributes identified as likely factors contributing to the significant mode choice differences found in the new urbanist neighborhood were: 1) the walkable distance between residences and the commercial center, 2) the neighborhood’s network of sidewalks, trails and pedestrian-oriented design, and 3) the availability of direct bus routes from the neighborhood to popular local destinations (A. J. Khattak & Rodriguez, In press).

These studies have addressed the issue of the built environment’s association with physical activity and weight status at several different geographic levels (metropolitan, county, and neighborhood). The study by Ewing, et al. (2003) looked at metropolitan and county-level areas while Frank, et al. (2004) examined the area within a one-kilometer buffer around participants’ residences. To date, only the Saelens, et al. (2003) study compared residents from two defined neighborhoods to examine physical activity and weight status. Although the Saelens study focused on neighborhoods characterized as having high or low walkability, neither neighborhood was a new urbanist community. Rodriguez and colleagues (In press) matched a new urbanist neighborhood with a conventional suburban development and examined differences in physical activity and travel behavior between residents, but their analysis did not include a weight status variable. To address the gap in the existing literature, this study compares residents of a new urbanist neighborhood to residents of a conventional suburban neighborhood to determine if the type of neighborhood is related to physical activity and/or weight status (i.e. BMI).
3. Methods

Study Design

Using a cross-sectional study design (Shadish, Cook, & Campbell, 2002) a large new urbanist neighborhood located in the Chapel Hill-Carrboro area of North Carolina was matched with five conventional suburban neighborhoods located in the same area. A map of the new urbanist neighborhood and conventional suburban neighborhoods areas are shown in Figure 2. The conventional suburban neighborhoods and the new urbanist neighborhood shared several common characteristics, while differing in aspects relevant to this study. The neighborhoods were matched on average assessed value of single-family homes in the neighborhoods (according to cadastral records), age of development and regional accessibility. Several key differences exist between the neighborhood types that allow them to be classified as either new urbanist or conventional suburban neighborhoods. Table 1 lists characteristics of the study sites and highlights several differences including street design and connectivity, parcel size and the presence of varied housing types, mixed land uses and transit availability. To control for differences in public service factors, such as school quality, all neighborhood candidates were limited to the Chapel Hill-Carrboro school district.
Figure 2. Maps of the two neighborhood types

Land use map of the five conventional suburban neighborhoods

Land use map and different types of housing in the new urbanist neighborhood

Maps adapted from A. Khattak et al., 2004
Table 1. Characteristics of the new urbanist and five conventional suburban neighborhoods

<table>
<thead>
<tr>
<th></th>
<th>New urbanist neighborhood</th>
<th>Conventional suburban neighborhoods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of households</td>
<td>920</td>
<td>891</td>
</tr>
<tr>
<td>Single-family detached homes</td>
<td>611</td>
<td>891</td>
</tr>
<tr>
<td>Apartments/Condominiums</td>
<td>309&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td>Average lot size</td>
<td>6,969 sq. ft. (0.16 acre lots)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>16,812 sq. ft. (0.39 acre lots)</td>
</tr>
<tr>
<td>Number of employees</td>
<td>Approx. 432&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td><strong>Diversity of land uses</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uses present</td>
<td>Retail, Office, School, Residential</td>
<td>Residential</td>
</tr>
<tr>
<td>Commercial sq. ft.</td>
<td>Approx. 200,000&lt;sup&gt;d, e&lt;/sup&gt;</td>
<td>0</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Street pattern</td>
<td>Modified Grid</td>
<td>Curvilinear</td>
</tr>
<tr>
<td>Street connectivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td># of 3 or 4-way intersections</td>
<td>51</td>
<td>27</td>
</tr>
<tr>
<td>Cul-de-sacs and dead ends</td>
<td>2</td>
<td>56</td>
</tr>
<tr>
<td>Average block length (ft)</td>
<td>2,080</td>
<td>5,648</td>
</tr>
<tr>
<td>Median block length (ft)</td>
<td>1,209</td>
<td>3,419</td>
</tr>
<tr>
<td>Pedestrian provisions</td>
<td>Sidewalks on both sides of the street, parks, street furniture and trees, bicycle and walking trails and bicycle racks</td>
<td>Sidewalk on one side of the street, parks, street trees</td>
</tr>
<tr>
<td><strong>Date of Development</strong></td>
<td>Late 1990’s</td>
<td>Late 1980’s – 1990’s</td>
</tr>
<tr>
<td><strong>Average Housing Value</strong></td>
<td>$301,787</td>
<td>$303,357</td>
</tr>
<tr>
<td><strong># of Buslines Serving Area</strong></td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

<sup>a</sup> 197 apartments and 112 condominiums  
<sup>b</sup> Calculation does not include lot size approximations for apartments or condominiums  
<sup>c, d</sup> Calculation does not include the school (90,000 sq. ft.), daycare center (6,000 sq. ft.), or church (27,000 sq. ft.)  
<sup>e</sup> Retail sq. ft. = 30,000 sq. ft. of 50,000 sq. ft is built; office sq. ft. = 95,000 sq. ft. of 145,000 sq. ft., is built.

Table adapted for: (A. Khattak et al., 2004) (A. J. Khattak & Rodriguez (In press)

**Survey Design**
To obtain cross-sectional information, from March through May 2003, a mail-out mail-back self-administered survey was sent to each head of household in the 920 new urbanist neighborhood residences and 891 conventional suburban neighborhood residences. Prior to receiving the survey, a postcard explaining the study and forthcoming survey and travel diary was mailed to each residence. To increase response rates, a reminder postcard was mailed to each non-respondent household followed by up to two telephone calls. A $10 certificate useable at an area grocery store also served as an incentive for returning a completed survey.

The survey instrument (Appendix A) was comprised of two sections. The first section solicited information on household characteristics and composition and demographic details; travel behavior and patterns; height and weight information; physical activity data; and attitudes and preferences related to the built environment. The second section contained a one-day travel diary with instructions. The physical activity questions used in the survey were borrowed from the Centers for Disease Control and Prevention BRFSS year 2001 module on moderate and vigorous physical activity, and the travel diary design and many of the survey questions were based on the 2001 National Household Transportation Survey (NHTS).
The survey assessed physical activity by asking heads of households if during a usual week they participate in “moderate physical activities lasting at least 10 minutes at a time, such as brisk walks, bicycling, vacuuming, gardening, or anything else [other than occupational related physical activity] that causes small increases in breathing or heart rate.” If the participant responded “yes” to the moderate physical activity question, he/she was instructed to list the number of days per week they participated in moderate physical activity for at least 10 minutes at a time and specify the number of hours and minutes per day they spent engaged in those activities.

Household heads were then asked if during a usual week they engaged in “vigorous physical activity for at least 10 minutes at a time, such as running, aerobics, heavy yard work, or anything else that causes large increases in breathing or heart rate.” If the participant responded “yes” to the vigorous physical activity question, he/she was instructed to report the number of days per week they participated in vigorous physical activities for at least 10 minutes at a time and specify the number of hours and minutes per day they spent engaged in those activities. The reliability (W. J. Brown, Trost, Bauman, Mummerly, & Owen, 2004; Evenson, Eyler, Wilcox, Thompson, & Burke, 2003; Evenson & McGinn, In press) and validity (Ainsworth et al., 2000; Strath, Bassett, Ham, & Swartz, 2003) of these BRFSS physical activity questions are examined elsewhere.

The travel diary collects trip data on: origin and destination, duration, time of day, purpose, mode, distance, and out-of-pocket costs. Trips were stratified by non-motorized or motorized using data from the mode type used for each trip. Non-motorized travel captured trips taken by foot or bicycle, and motorized travel encompassed trips made by private automobile or public transit (i.e., bus). The definition of a trip for this study expanded the NHTS definition of trip to include travel from one place to another involving movement of more than 300 feet (U.S. Department of Transportation, 2003). This modification was made to better capture physical activity travel such as walking pets, walking/jogging for exercise and riding bicycles. Walking and bicycling trips that originated and terminated at home with no intermediate stops, and all trips taken for exercise, relaxation and leisure were coded as “recreational/leisure physical activity trips.” Trips that began and ended at different locations and taken to access a destination were considered utilitarian trips and classified as “motorized utilitarian trips” and “utilitarian physical activity trips” depending on the primary mode of transport used for the trips.

Section one (questionnaire) of the survey instrument was to be completed by the head of household at each address. Section two (travel diary) was to be filled out by all household members over 15 years of age. The household members were asked to complete the one-day travel diary on a Tuesday, Wednesday or Thursday. The findings presented in this paper only include data collected from the heads of household, as these participants were the only ones asked to complete both survey sections.

**Outcome Measures**

Body Mass Index (BMI) is an inexpensive and user-friendly measure that indicates weight status based on an individual’s weight and height (National Center for Chronic Disease Prevention and Health Promotion, 2005). BMI is significantly correlated with total body fat content for the
majority of individuals (L. National Heart, and Blood Institute (NHLBI), 1998). The standard BMI equation is weight in kilograms divided by height in meters squared (kg/m$^2$ = BMI). In this study, heads of household in each neighborhood type were asked to report their weight in pounds and height in feet and inches. The validity of self-reported height and weight measurements has been examined elsewhere (Fonseca Mde, Faerstein, Chor, & Lopes, 2004; Newell, Girgis, Sanson-Fisher, & Savolainen, 1999; Spencer, Appleby, Davey, & Key, 2002; Villanueva, 2001). These self-reported height and weight data were converted to kilograms and meters using the conversion of one pound = 0.454 kilograms and one foot = 0.305 meters. Each participant’s BMI was calculated as kg/m$^2$.

Using the BMI, each participant’s weight status was assessed according to the Centers for Disease Control and Prevention (CDC) adult weight status classification scheme for BMI: underweight = 18.5, normal weight = 18.5 to 24.9, overweight = 25 to 29.9, and obese = 30 (National Center for Chronic Disease Prevention and Health Promotion, 2005). These BMI ranges are based on the effect body weight has on disease and death, in that as BMI increases, the risk for certain diseases increases (World Health Organization, 1995).

Binary variables (0/1; 0 = no, 1 = yes) for normal weight, overweight, and obese were created, and each household head was classified as normal weight, overweight or obese if his/her BMI was 18.5 to 24.9, 25 to 29.9, = 30.0 or = 25.0, respectively. Heads of household with a BMI = 18.5 were classified as underweight and excluded from analysis. The CDC’s adult weight status classification scheme does not vary by age or sex and defines an adult as a person age 20 years or older, whereas for children (ages 2 to 19 years old), the interpretation of the BMI results are based on age- and sex-specific growth charts (National Center for Chronic Disease Prevention and Health Promotion, 2005). In this study, all heads of household were at least 20 years of age. The head of household had his/her BMI calculated and categorized to determine his/her weight status classification. From these data, four outcome measures were calculated: BMI (continuous), normal weight (binary), overweight (binary), and obese (binary).

Explanatory Variables

Neighborhood Built Environment

Measures of the built environment frequently used in the transportation, planning, and recently public health bodies of literature are: diversity in land use; population-, employment- and housing densities; and street network design (Cervero & Duncan, 2003; Cervero & Kockelman, 1997; Ewing & Cervero, 2001; SL Handy et al., 2002; D. A. Rodriguez, Brown, & Troped, Under review; Saelens, Sallis, & Frank, 2003). The research design of this study accounted for many of these measures at a neighborhood level and allowed binary variables for new urbanist and conventional suburban neighborhoods to adequately capture the two distinctly different urban forms. Additionally, households in the new urbanist neighborhood were stratified by dwelling type (single-family units or multi-family units comprised of apartments and condominiums) to identify potential differences between the household heads in each housing type relative to the conventional suburban neighborhood group. Thus, three dummy variables represented the neighborhood and dwelling type with yes designated by 1 and no by 0. Two dummy variables for the new urbanist neighborhood were created, one dummy variable coded as
I for the single-family dwelling, and another dummy variable coded as 1 for the multi-family dwelling. The third dummy variable was coded 1 for conventional suburban neighborhood dwelling.

**Socio-demographics**
Socio-demographic variables have been found to be strong predictors of travel- and physical activity behaviors (L.D. Frank et al., 2004; Giles-Corti & Donovan, 2002; Murakami & Young, 1997; Robert & Reither, 2004). Age, sex, education, number of persons per household and vehicles per household were used to provide a description of the participants and to control for potential confounding effects on the BMI and being overweight or obese. Age was measured in years as a continuous variable; sex was measured with a dummy variable (0/1) with male coded as 1; education was measured using a dummy variable with having a bachelor’s degree or higher coded as 1 and not completing at least a four-year post secondary degree coded as 0; and the number of cars per household and number of residents per household were each measured a continuous variables. Household income was indirectly controlled through the research design, as one of the matching criteria for the neighborhoods was similar average home value.

**Transportation**
Travel behaviors were captured using responses to a modified NHTS travel diary. Heads of household were asked to record all their trips for their one travel day. From the diary data collected, the mode (non-motorized or motorized) and purpose of each trip was determined (recreational or utilitarian) and the corresponding trip frequency was summed for each head of household. This resulted in three transportation behavior measures per household head: number of motorized utilitarian trips, number of utilitarian physical activity trips, and number of recreation/leisure physical activity trips.

**Physical Activity**
Physical activity was assessed using questions from BFRSS survey year 2001 module on moderate and vigorous physical activity from BFRSS survey (Centers for Disease Control and Prevention (CDC), 2001). Using the participants’ responses to these questions, four measures of physical activity were calculated for each head of household. The total amount of time engaged in moderate and vigorous physical activity (MVPA) in a usual week was measured as a continuous variable. Three dummy variables (0/1; 0 = no, 1 = yes) were created for categorizing each participant’s physical activity level. Heads of household were categorized as meeting or not meeting the CDC/American College of Sports Medicine/Healthy People 2010 recommendations for weekly physical activity. For household heads that participated in some physical activity but at an amount below current recommendations, they were categorized as active but insufficient. Heads of household that reported not engaging in any moderate or physical activity lasting 10 consecutive minutes in a usual week were classified as physically inactive.

To summarize the explanatory variables, the built environment measures were captured at the neighborhood level and categorized as either conventional suburban neighborhood, new urbanist

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3 Adults should engage in moderate intensity physical activity for at least 30 minutes on 5-7 days per week or engage in vigorous intensity physical activity for 20 minutes or more on 3-7 days per week ((Pate et al., 1995).
single-family dwelling, or new urbanist multi-family dwellings. Socio-demographics included age, sex, number of vehicles per household, number of household members and education level. Transportation was divided by motorized and non-motorized modes and the number of trips was captured for utilitarian and recreational trips. Physical activity was measured by total MVPA time and the various forms of meeting or failing to recommended levels of physical activity. Table 2 provides a overall summary of the outcome and explanatory variables examined in this study along with defining how each was measured.

Table 2. List of variables and their measurement types used to examine the characteristics of the heads of household in this study

<table>
<thead>
<tr>
<th>Construct and Variables</th>
<th>Measurement type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weight Status</strong></td>
<td></td>
</tr>
<tr>
<td>Body mass index (BMI)</td>
<td>Continuous</td>
</tr>
<tr>
<td>Normal weight</td>
<td>0 = not normal weight</td>
</tr>
<tr>
<td></td>
<td>1 = normal weight</td>
</tr>
<tr>
<td>Overweight</td>
<td>0 = not overweight</td>
</tr>
<tr>
<td></td>
<td>1 = overweight</td>
</tr>
<tr>
<td>Obese</td>
<td>0 = not obese</td>
</tr>
<tr>
<td></td>
<td>1 = obese</td>
</tr>
<tr>
<td><strong>Neighborhood Build Environment</strong></td>
<td></td>
</tr>
<tr>
<td>Conventional suburban neighborhood household</td>
<td>0 = does not live in this neighborhood type</td>
</tr>
<tr>
<td></td>
<td>1 = lives in this neighborhood type</td>
</tr>
<tr>
<td>New urbanist single-family dwelling household</td>
<td>0 = does not live in this neighborhood type</td>
</tr>
<tr>
<td></td>
<td>1 = lives in this neighborhood type</td>
</tr>
<tr>
<td>New urbanist multi-family dwelling household</td>
<td>0 = does not live in this neighborhood type</td>
</tr>
<tr>
<td></td>
<td>1 = lives in this neighborhood type</td>
</tr>
<tr>
<td><strong>Socio-demographic</strong></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>Continuous</td>
</tr>
<tr>
<td>Sex</td>
<td>0 = female</td>
</tr>
<tr>
<td></td>
<td>1 = male</td>
</tr>
<tr>
<td>Education</td>
<td>0 = does not have a bachelor’s degree</td>
</tr>
<tr>
<td></td>
<td>1 = has a bachelor’s degree or higher</td>
</tr>
<tr>
<td>Number of persons per household</td>
<td>Continuous</td>
</tr>
<tr>
<td>Number of vehicles per household</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Transportation Trip Frequency</strong></td>
<td></td>
</tr>
<tr>
<td>Number of motorized utilitarian trips</td>
<td>Continuous</td>
</tr>
<tr>
<td>Number of utilitarian physical activity trips</td>
<td>Continuous</td>
</tr>
<tr>
<td>Number of utilitarian recreational/leisure trips</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Physical Activity</strong></td>
<td></td>
</tr>
<tr>
<td>Number of hours per week of moderate and vigorous physical activity</td>
<td>Continuous</td>
</tr>
<tr>
<td>Meeting recommendations for weekly physical activity</td>
<td>0 = does not meet recommendations</td>
</tr>
<tr>
<td></td>
<td>1 = meets recommendations</td>
</tr>
<tr>
<td>Physically activity but insufficient to meet recommendations</td>
<td>0 = meets physical activity recommendations or is physically inactive</td>
</tr>
<tr>
<td></td>
<td>1 = is physically activity but insufficient</td>
</tr>
<tr>
<td>Physically inactive</td>
<td>0 = acquires some amount of physical activity</td>
</tr>
<tr>
<td></td>
<td>1 = is physically inactive</td>
</tr>
</tbody>
</table>
**Data analysis procedures**
Statistical analysis was conducted using SPSS 12.0 (Chicago, IL). The differences in socio-demographic, weight status, transportation behaviors and physical activity behavior measures by neighborhood and dwelling type were assessed using bivariate analysis. Independent sample t-tests not assuming equal variances were used for continuous variables. Two proportions tests and z-scores were used when the variables were binary. All significance tests were one-tailed and a critical \( p \)-value of 0.05 (95% confidence level) was used to determine statistical significance unless otherwise noted.

Multiple variable regression was used to further examine the variance detected between the neighborhood built environment and the body composition beyond any variance resulting from the socio-demographic, travel behavior and physical activity behavior characteristics. For the regressions, two sets of models were constructed: one set was ordinary least squares (OLS) regressions for BMI (continuous) as the dependent variable; the other set was binary logistic regression with overweight or obese (binary) as the dependent variable. Each set of regressions was comprised of several models. The first models examining the impact neighborhood design had on the dependent variables (BMI or overweight/obese) for heads of household of new urbanist single- and multi-family dwellings while controlling for socio-demographic variables including age, sex, college education, number of automobiles per household and size of household. The second model in each set built on the initial model by including variables measuring motorized- and non-motorized trip frequency and physical activity duration. To determine if the associations between the household heads’ behaviors (travel and physical activity) and weight status were unique to residents of a particular neighborhood, the developments were stratified by type of neighborhood (conventional suburban and new urbanist neighborhood). The third and fourth regression models (stratified models) were conducted using all the socio-demographic, travel behavior and physical activity variables listed previously.

The results of the binary logistic models were used to calculate the adjusted odds ratios (OR) and 95% confidence intervals for the new urbanist neighborhood design variables, the motorized and non-motorized trip frequency variables and the physical activity variable.

**4. Results**

The overall response rate to the household survey mailed to the 920 new urbanist residences and the 891 conventional suburban residences was 25.0%. The response rates by neighborhood type were 23.6% (n=210) for the conventional neighborhood and 26.4% (n = 243) for the new urbanist neighborhood [27.5% (168/611) for single-family homes and 24.3% (75/309) for apartment/condominiums]. Of the 453 total respondents, 27 participants failed to provide height and/or weight information needed to calculate BMI and 8 participants had a BMI classified as under-weight. Two heads of household did not report their gender, one did not provide the number of motor vehicles in the household, and one failed to provide his/her education level. Additionally, 29 participants were missing physical activity data and three other observations were removed because their reported physical activity was more than five standard deviations.
away from the mean. This resulted in 382 valid household head’s responses when using BMI and BMI derived outcome measures.

Data collected on the one-day travel diary was used to assess the frequency of trips made by the heads of household using motorized and non-motorized modes. Although the travel diary instructions indicated that the diaries should be completed on a Tuesday, Wednesday, or Thursday, some diaries were filled out for Mondays or Fridays and a small portion were filled out on weekends. Over ninety-eight percent of the one-day travel diaries submitted were completed for a weekday, Monday through Friday, with the remaining 1.5% (5/324) diaries being filled out on Saturday or Sunday. Of the 382 participants identified above, 58 respondents had missing travel diary data, which resulted in a sample of 324 heads of household responses eligible for comparing trip characteristics by neighborhood and dwelling types when using regression modeling.

**Socio-demographics**

The socio-demographic characteristics of the heads of household in each neighborhood are shown in Table 3. Comparisons between residents of single-family dwellings show that household heads in the new urbanist neighborhood had fewer household members and fewer automobiles than the heads of household residing in the conventional suburban neighborhoods. Multi-family new urbanist household heads tended to be younger, were more likely to be female, and were more likely to have a smaller household and possess fewer automobiles than their conventional suburban neighborhood counterparts. While education was not significantly different between the neighborhoods and dwelling types, the percentage of household heads holding a bachelor’s degree or higher (= 89%) was well above the national median of 29.4% and the North Carolina average of 27.3% (National Center for Chronic Disease Prevention and Health Promotion, 2004).

| Table 3. Average values for socio-demographic characteristics of household heads (n = 382) by neighborhood and dwelling type |
|---|---|---|---|---|---|---|---|---|---|
| | Conventional suburban neighborhoods | | New urbanist neighborhood | | | | | |
| | Single-family (n = 181) | Single-family (n = 140) | Multi-family (n = 61) | | | | | |
| Age (years) | Mean SD | Mean SD T p-value | Mean SD T p-value | | | | | |
| 46.8 10.4 | 45.2 13.2 1.22 0.223 | 37.2 16.0 4.24 0.000*** | | | | | |
| Male (%) | 63.5 --- | 53.6 --- -1.80 0.071* | 27.9 --- -4.84 0.000*** | | | | | |
| Household size | 3.4 1.2 | 2.7 1.3 4.90 0.000*** | 1.5 0.8 13.34 0.000*** | | | | | |
| Automobiles per household | 2.2 0.6 | 1.8 0.6 4.45 0.000*** | 1.3 0.5 10.46 0.000*** | | | | | |
| Bachelor's degree or higher (%) | 92.8 ---- | 95.7 ---- 1.09 0.275 | 88.5 ---- -1.05 0.292 | | | | | |

*p < 0.10 All tests shown are two-tailed.

**p < 0.05

***p < 0.01

a For continuous variables, t-tests with equal variances not assumed were used.

b For dichotomous variables, two proportions tests and z-scores were used.
Body Mass and Weight Status
The findings between body mass, weight status and neighborhood type are presented in Table 4. The average of the BMI values calculated for each neighborhood and dwelling type indicates that heads of household in both neighborhood types on average were within the BMI range to considered normal weight (BMI between 18.5 and 24.9). Heads of household in the new urbanist multi-family units had an average BMI (23.8, \( p = 0.016 \)) lower than the BMI (24.9) household heads living in the conventional suburban neighborhoods. However, the BMI of household heads living in the new urbanist single-family dwellings did not significantly differ from the BMI of their conventional suburban neighborhood contemporaries. Similar results were also found between heads of household classified as overweight. The percent of overweight household heads in the new urbanist multi-family dwellings was 27.9% compared to 40.3% (\( p = 0.041 \)) in the conventional suburban neighborhoods.

<table>
<thead>
<tr>
<th></th>
<th>Conventional suburban neighborhoods</th>
<th>New urbanist neighborhood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-family ((n = 181))</td>
<td>Single-family ((n = 140))</td>
</tr>
<tr>
<td></td>
<td>Mean (\pm) SD</td>
<td>Mean (\pm) SD (t) (p)-value</td>
</tr>
<tr>
<td>BMI (^a)</td>
<td>24.9 (\pm) 3.2</td>
<td>24.6 (\pm) 3.6 (0.78) (0.218)</td>
</tr>
<tr>
<td>Normal weight (^b)</td>
<td>54.1 ---</td>
<td>58.6 --- (0.79) (0.214)</td>
</tr>
<tr>
<td>Overweight (^b)</td>
<td>40.3 ---</td>
<td>35.7 --- (-0.84) (0.200)</td>
</tr>
<tr>
<td>Obese (^b)</td>
<td>5.5 ---</td>
<td>5.7 --- (0.07) (0.471)</td>
</tr>
</tbody>
</table>

\(^{*}p < 0.10\)
\(^{**}p < 0.05\)
\(^{***}p < 0.01\)

\(^a\) For continuous variables, \(t\)-tests with equal variances not assumed were used.
\(^b\) For dichotomous variables, two proportions tests and \(z\)-scores were used.

No significant difference in obesity levels was found between the neighborhood or dwelling types. Due to the overall low prevalence of obesity among heads of household \((n = 22; 12\) in the new urbanist neighborhood and \(10\) in the conventional neighborhood\), participants classified as obese were combined with overweight household heads to create a new variable—overweight or obese. The “overweight or obese” variable (not shown) yielded no significant difference between those living in either single-family or multi-family units relative to those living in the conventional suburban neighborhoods.

Trip Making and Travel Behavior
Data from the travel diary revealed that both single- and multi-family household heads in the new urbanist neighborhood made almost one \(0.76\) fewer motorized trip per day than the heads of household living in the conventional suburban neighborhoods. Table 5 shows that the new urbanist heads of household in both dwelling types made significantly more trips by walking or bicycling than their conventional neighborhood counterparts. Stratifying these physical activity
trips by primary purpose (utility versus recreation) reveals that utilitarian physical activity trips constitute the bulk of the difference between neighborhood types. Single- and multi-family new urbanist heads of household each made 3.1 more utilitarian physical activity trips than the conventional suburban household heads. This trip differential was calculated by dividing the utilitarian physical activity trip means for the new urbanist dwelling types by the mean number of utilitarian physical activity trips made by the conventional suburban neighborhood group (.74/.24 and .75/.24).

Table 5. Daily frequency of motorized vehicle and non-motorized trips for household heads (n = 324) by neighborhood and dwelling type

<table>
<thead>
<tr>
<th></th>
<th>Conventional suburban neighborhoods</th>
<th>New urbanist neighborhood</th>
<th>t</th>
<th>p-value</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>p-value</th>
<th>Mean</th>
<th>SD</th>
<th>T</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-family</td>
<td>Single-family</td>
<td>Multi-family</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(n = 159)</td>
<td>(n = 117)</td>
<td>(n = 48)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motorized Utilitarian Trips</td>
<td>Mean 4.75  SD 2.49</td>
<td>Mean 3.99  SD 2.01</td>
<td>t 2.80  p-value 0.002***</td>
<td>Mean 4.02  SD 2.31</td>
<td>t 1.89  p-value 0.003***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Physical Activity Trips</td>
<td>Mean 0.48  SD 1.12</td>
<td>Mean 1.05  SD 1.73</td>
<td>t -3.10  p-value 0.000***</td>
<td>Mean 1.15  SD 1.27</td>
<td>t -3.25  p-value 0.001***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilitarian Physical Activity Trips</td>
<td>Mean 0.24  SD 0.82</td>
<td>Mean 0.74  SD 1.62</td>
<td>t -3.09  p-value 0.000***</td>
<td>Mean 0.75  SD 1.21</td>
<td>t -2.74  p-value 0.001***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreation/Leisure Physical Activity Trips</td>
<td>Mean 0.25  SD 0.56</td>
<td>Mean 0.31  SD 0.59</td>
<td>t -0.88  p-value 0.088*</td>
<td>Mean 0.40  SD 0.64</td>
<td>t -1.46  p-value 0.189</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p < 0.10  
** p < 0.05  
*** p < 0.01  

_t_-tests with equal variances not assumed were used.
Physical Activity Level
A comparison between head of household classified as meeting or not meeting current physical activity recommendations found no significant differences across neighborhoods or dwelling types (Table 6). Similarly, no difference was detected between neighborhood and dwelling types for respondents classified as insufficiently active or physically inactive. For each neighborhood, the amount of time household heads spent per week engaged in moderate and vigorous physical activity (MVPA) exceeded 4½ hours with no significant difference detected between neighborhood and dwelling types.

Table 6. Average MVPA and CDC physical activity recommendations of household heads (n = 382) by neighborhood and dwelling type

<table>
<thead>
<tr>
<th></th>
<th>Conventional suburban neighborhood</th>
<th>New urbanist neighborhood</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-family</td>
<td>Multi-family</td>
</tr>
<tr>
<td>(n = 181)</td>
<td>(n = 140)</td>
<td>(n = 61)</td>
</tr>
<tr>
<td>Meet physical activity recommendations (%)a</td>
<td>50.8 ---</td>
<td>55.0 ---</td>
</tr>
<tr>
<td>Physically active but insufficient (%)a</td>
<td>42.0 ---</td>
<td>38.6 ---</td>
</tr>
<tr>
<td>Physically inactive (%)a</td>
<td>7.2 ---</td>
<td>6.4 ---</td>
</tr>
<tr>
<td>Duration of MVPA (hrs*wk⁻¹)b</td>
<td>4.6 4.2</td>
<td>4.9 4.8</td>
</tr>
</tbody>
</table>

* p < 0.10  
** p < 0.05  
*** p < 0.01  

a For dichotomous variables, two proportions tests and z-scores were used.  
b For continuous variables, t-tests with equal variances not assumed were used.

Regression Models of BMI and Weight Status
Two sets of regression models were run to examine the influence neighborhood type had on body composition for the heads of household in the new urbanist and conventional suburban neighborhoods. The first set of models (Models 1 & 2 in Table 7) employed OLS regression. The second set of models (Model 3 in Figure 3 and Model 4 in Figure 4) utilized binary logistic regression to examine the influence neighborhood type had on the likelihood of being overweight or obese. All models controlled for the following socio-demographic variables: age, sex, college education, number of persons in household, and vehicles per household. In order to compare across models, all the socio-demographic control variables were included in each model regardless of their significance. All regression models were significant at a level of confidence = 99%.

The unstandardized coefficients, corresponding t-stats and p-values for two OLS regressions are displayed in Table 7. Model 1 shows the relationship between the new urbanist neighborhood dwelling types and BMI while controlling for socio-demographics. Model 2 expands the first model by including variables of travel and physical activity behaviors. The models show that the
new urbanist neighborhood variables, single-family and multi-family dwellings, were not significantly associated with BMI after accounting for socio-demographic characteristics, travel behavior and physical activity.

Of the socio-demographic control variables used in Models 1 & 2, age and sex (being male) remained significant at a level = 95%, while college education, persons per household and vehicles per household were non-significant in these models. According to Model 2, each one-year increase in age associated with a modest 0.06 increase in BMI. Being male was related to an average BMI increase of 2.0 units.

The coefficients in Model 2 for non-motorized trip frequency and the duration of weekly moderate and vigorous physical activity (MVPA) reveal a significant association with BMI. On average, each daily (travel diary was completed for one day) utilitarian trip taken via walking or bicycling was related to a 0.30 lower BMI ($p = 0.031$), and each recreation physical activity trip was associated with a reduction in BMI, although the significance was only at the 90% level ($p = 0.084$). Each hour per week spent obtaining MVPA was significantly associated with a 0.14 ($p < 0.000$) reduction in BMI for household heads.

Table 7. OLS regression modeling the associations between BMI and neighborhood type, travel behaviors and physical activity controlling for socio-demographic characteristics (n = 324)

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Coefficient</th>
<th>SE</th>
<th>t-stat</th>
<th>p-value</th>
<th>Coefficient</th>
<th>SE</th>
<th>t-stat</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>20.50</td>
<td>1.34</td>
<td>15.27</td>
<td>0.000***</td>
<td>21.35</td>
<td>1.36</td>
<td>15.65</td>
<td>0.000***</td>
</tr>
<tr>
<td>New Urbanist Single-family</td>
<td>0.34</td>
<td>0.40</td>
<td>0.85</td>
<td>0.398</td>
<td>0.54</td>
<td>0.39</td>
<td>1.38</td>
<td>0.167</td>
</tr>
<tr>
<td>New Urbanist Multi-family</td>
<td>0.57</td>
<td>0.66</td>
<td>0.86</td>
<td>0.390</td>
<td>0.87</td>
<td>0.65</td>
<td>1.34</td>
<td>0.181</td>
</tr>
<tr>
<td>Age</td>
<td>0.05</td>
<td>0.02</td>
<td>3.39</td>
<td>0.001***</td>
<td>0.06</td>
<td>0.02</td>
<td>3.69</td>
<td>0.000***</td>
</tr>
<tr>
<td>Sex (Male = 1)</td>
<td>2.18</td>
<td>0.38</td>
<td>5.80</td>
<td>0.000***</td>
<td>2.00</td>
<td>0.37</td>
<td>5.37</td>
<td>0.000***</td>
</tr>
<tr>
<td>College (College = 1)</td>
<td>-0.58</td>
<td>0.17</td>
<td>0.45</td>
<td>0.242</td>
<td>-0.68</td>
<td>0.71</td>
<td>-0.96</td>
<td>0.336</td>
</tr>
<tr>
<td>Number of persons in home</td>
<td>0.14</td>
<td>0.72</td>
<td>1.17</td>
<td>0.427</td>
<td>0.20</td>
<td>0.31</td>
<td>1.23</td>
<td>0.219</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>0.19</td>
<td>0.31</td>
<td>-0.80</td>
<td>0.655</td>
<td>0.22</td>
<td>0.16</td>
<td>0.73</td>
<td>0.467</td>
</tr>
<tr>
<td>Number of vehicle trips</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.04</td>
<td>0.07</td>
<td>-0.48</td>
<td>0.634</td>
</tr>
<tr>
<td>Utilitarian trip frequency (PA)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.30</td>
<td>0.14</td>
<td>-2.16</td>
<td>0.031**</td>
</tr>
<tr>
<td>Recreation trip frequency (PA)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.51</td>
<td>0.29</td>
<td>-1.73</td>
<td>0.084*</td>
</tr>
<tr>
<td>Duration of MVPA (Hrs*wk$^{-1}$)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>-0.14</td>
<td>0.04</td>
<td>-3.56</td>
<td>0.000***</td>
</tr>
</tbody>
</table>

R Square                      | 0.17        |      |        |          | 0.23        |      |        |          |
Adjusted R Square             | 0.15        |      |        |          | 0.20        |      |        |          |
Std. Error of the Estimate    | 3.08        |      |        |          | 3.00        |      |        |          |
F                              | 9.39        |      |        |          | 8.28        |      |        |          |
Significance                  | 0.000       |      |        |          | 0.000       |      |        |          |

*p < 0.10
**p < 0.05
***p < 0.01
The binary logistic regression models used “overweight or obese” as the dependent variable. Due to the low prevalence of obesity among head of household in both neighborhoods (n = 22), the variable for “obese” and “overweight” were collapsed into a single variable, “overweight or obese” and used as the dependent variable in the models. Running the logistic models using only “overweight” as the dependent variable (not shown) resulted in the same variable being significant when the “overweight or obese” variable was used.

Examining the relationship between neighborhood type and being overweight or obese while controlling for socio-demographics found that for heads of household, residing in the new urbanist neighborhood did not significantly reduce the likelihood of being overweight or obese. Figure 3 displays the odds ratio and 95% confidence interval (CI) for the household heads living in the new urbanist single- and multi-family dwellings as calculated by Model 3. Of the socio-demographic variables (not shown in Figure 3), only age ($p < 0.000$) and being male ($p < 0.000$) were significantly associated with an increased likelihood of being overweight or obese.

Model 4 builds on the previous model by adding variables measuring the number of motorized trips, non-motorized physical activity trips and duration of physical activity. The results of Model 4 are presented as odds ratios with 95% CI in Figure 4. The new urbanist neighborhood variable did not significantly affect the odds of being overweight or obese, rather the findings indicate that a daily physical activity trip for recreation taken by household heads translated into a 42% reduction in the odds of being overweight or obese (OR: 0.58; CI: 0.34 – 0.97). The duration of weekly MVPA was significant and negatively associated with being overweight or obese, with each hour per week of moderate and vigorous physical activity reducing the likelihood of being overweight or obese by 7% (OR: 0.93; CI 0.88 – 0.99). Of the socio-demographic variables included in the model, age and sex were statistically significant at a level > 95%. Each year aged was associated with a 4% increase in the odds of being overweight or obese (OR: 1.04; CI 1.02 – 1.07). Being male increased the odds of being overweight or obese threefold (OR: 3.11; CI 1.86 – 5.22).
Figure 4. The adjusted odds ratio and 95% confidence interval of the likelihood of being overweight or obese for household heads residing in new urbanist single- and multi-family units controlling for socio-demographic characteristics, travel behaviors and physical activity (n =324)

<table>
<thead>
<tr>
<th>Recreation PA Duration of MVPA</th>
<th>New Urbanist Single-Family Unit</th>
<th>New Urbanist Multi-family Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.00</td>
<td>1.05</td>
</tr>
<tr>
<td></td>
<td>2.00</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td>3.00</td>
<td>0.84</td>
</tr>
<tr>
<td></td>
<td>4.00</td>
<td>0.58**</td>
</tr>
<tr>
<td></td>
<td>5.00</td>
<td>0.93**</td>
</tr>
<tr>
<td></td>
<td>6.00</td>
<td></td>
</tr>
</tbody>
</table>

* $p < 0.10$
** $p < 0.05$
*** $p < 0.01$

= adjusted odds ratio. −, − = upper and lower bounds of 95% CI

Stratified Analysis of BMI and Weight Status by Neighborhood
To determine if the associations between the household heads’ behaviors (travel and physical activity) and weight status were unique to residents of a particular neighborhood, the developments were stratified by type of neighborhood\(^4\) (conventional suburban and new urbanist neighborhood). These regression models were run using all the socio-demographic, travel behavior and physical activity variables previously listed.

The results of the OLS models stratified by neighborhood are summarized in Table 8. Model 5 suggests that other than age and sex, only duration of weekly MVPA was significantly associated with BMI for heads of household in the conventional suburban neighborhoods, with each hour

\(^4\) Due to the small sample size of the new urbanist multi-family dwellings in the sample (n = 48), the new urbanist multi-family dwellings and new urbanist single-family dwellings (n = 117) were collapsed into one New Urbanist variable when conducting the regression analysis stratified by neighborhood type. Running two models, one stratified by new urbanist single-family participants and the other by all new urbanist neighborhood participants resulted in all but one variable and corresponding significance level being the same in both models. Age was not significant (p = 0.10) in the new urbanist single-family dwelling strata, but was significant (p = 0.02) in the model stratified by the collapsed variable for new urbanist neighborhood.
per week engaged in MVPA translating into a lower BMI by 0.12 units. For the heads of household in the new urbanist neighborhood, the number of daily utilitarian physical activity trips and the duration of weekly MPVA were negatively associated with BMI (Model 6 in Table 8). The coefficients suggest that each utilitarian physical activity trip taken by a new urbanist household head significantly reduced BMI by 0.41 units (\( p = 0.019 \)). Each hour per week engaged in MVPA was significantly associated with a 0.17 reduction in BMI. These results confirm that utilitarian physical activity trips were associated with a lower BMI for heads of households in the new urbanist neighborhood, and were not associated with BMI for household heads in the conventional suburban neighborhoods.

Table 8. OLS regression modeling the associations between BMI and the travel behaviors and physical activity of heads of household (n = 324) stratified by neighborhood type

<table>
<thead>
<tr>
<th>Model 5 Conventional suburban neighborhoods (n = 159)</th>
<th>Model 6 New urbanist neighborhood (n = 165)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable Name</strong></td>
<td><strong>Coefficient</strong></td>
</tr>
<tr>
<td>Constant</td>
<td>21.39</td>
</tr>
<tr>
<td>Age</td>
<td>0.07</td>
</tr>
<tr>
<td>Sex (Male = 1)</td>
<td>2.33</td>
</tr>
<tr>
<td>College (Yes = 1)</td>
<td>-0.19</td>
</tr>
<tr>
<td>Number of persons in home</td>
<td>0.05</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>-0.93</td>
</tr>
<tr>
<td>Number of vehicle trips</td>
<td>0.10</td>
</tr>
<tr>
<td>Utilitarian trip frequency (PA)</td>
<td>-0.26</td>
</tr>
<tr>
<td>Recreation trip frequency (PA)</td>
<td>-0.35</td>
</tr>
<tr>
<td>Duration of MVPA</td>
<td>-0.12</td>
</tr>
</tbody>
</table>

R Square                                            | 0.23           |               | 0.24       |
Adjusted R Square                                    | 0.18           |               | 0.20       |
Std. Error of the Estimate                           | 2.87           |               | 3.13       |
F                                                    | 4.82           |               | 5.55       |
Significance                                         | 0.000          |               | 0.000      |

\* \( p < 0.10 \)
\** \( p < 0.05 \)
\*** \( p < 0.01 \)

Results from the logistic regression models stratified by neighborhood type are shown in Table 9 as Models 7 & 8. Model 7 found that only socio-demographic characteristics were associated with the likelihood of being overweight or obese for the conventional suburban neighborhood household heads. For new urbanist heads of household, the findings of Model 8 indicate that duration of MVPA was associated with a 9.0% (OR: 0.91; CI: 0.83 – 0.99) reduction in the odds of being overweight or obese for new urbanist household heads. Both of these models indicated no significant association between utilitarian physical activity trip frequency and the likelihood of being overweight or obese for heads of household in either neighborhood types.
Table 9. Binary logistic regression model estimation results with “overweight or obese” as the dependent variable and stratified by neighborhood type (n = 324)

<table>
<thead>
<tr>
<th>Model 7. Conventional suburban neighborhoods (n = 159)</th>
<th>Coefficient</th>
<th>SE</th>
<th>p-value</th>
<th>OR</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
<td>1.05</td>
<td>1.01 - 1.09</td>
</tr>
<tr>
<td>Sex</td>
<td>1.44</td>
<td>0.42</td>
<td>0.00</td>
<td>4.21</td>
<td>1.84 - 9.63</td>
</tr>
<tr>
<td>College</td>
<td>0.23</td>
<td>0.73</td>
<td>0.75</td>
<td>1.26</td>
<td>0.30 - 5.32</td>
</tr>
<tr>
<td>Number of persons in home</td>
<td>0.03</td>
<td>0.17</td>
<td>0.85</td>
<td>1.03</td>
<td>0.75 - 1.43</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>-0.06</td>
<td>0.33</td>
<td>0.87</td>
<td>0.95</td>
<td>0.49 - 1.81</td>
</tr>
<tr>
<td>Number of vehicle trips</td>
<td>0.04</td>
<td>0.08</td>
<td>0.63</td>
<td>1.04</td>
<td>0.89 - 1.21</td>
</tr>
<tr>
<td>Utilitarian trip frequency (PA)</td>
<td>-0.07</td>
<td>0.27</td>
<td>0.78</td>
<td>0.93</td>
<td>0.55 - 1.57</td>
</tr>
<tr>
<td>Recreation trip frequency (PA)</td>
<td>-0.32</td>
<td>0.37</td>
<td>0.39</td>
<td>0.73</td>
<td>0.35 - 1.51</td>
</tr>
<tr>
<td>Duration of MVPA</td>
<td>-0.05</td>
<td>0.04</td>
<td>0.26</td>
<td>0.95</td>
<td>0.87 - 1.04</td>
</tr>
<tr>
<td>Constant</td>
<td>-3.41</td>
<td>1.49</td>
<td>0.02</td>
<td>0.03</td>
<td>--- **</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Model 8. New urbanist neighborhood (n = 165)</th>
<th>Coefficient</th>
<th>SE</th>
<th>p-value</th>
<th>OR</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.04</td>
<td>0.01</td>
<td>0.00</td>
<td>1.04</td>
<td>1.01 - 1.07</td>
</tr>
<tr>
<td>Sex</td>
<td>0.68</td>
<td>0.39</td>
<td>0.08</td>
<td>1.97</td>
<td>0.91 - 4.23</td>
</tr>
<tr>
<td>College</td>
<td>-1.57</td>
<td>0.82</td>
<td>0.06</td>
<td>0.21</td>
<td>0.04 - 1.04</td>
</tr>
<tr>
<td>Number of persons in home</td>
<td>0.20</td>
<td>0.17</td>
<td>0.25</td>
<td>1.22</td>
<td>0.87 - 1.71</td>
</tr>
<tr>
<td>Number of vehicles</td>
<td>0.11</td>
<td>0.32</td>
<td>0.74</td>
<td>1.11</td>
<td>0.59 - 2.09</td>
</tr>
<tr>
<td>Number of vehicle trips</td>
<td>-0.03</td>
<td>0.09</td>
<td>0.76</td>
<td>0.97</td>
<td>0.82 - 1.16</td>
</tr>
<tr>
<td>Utilitarian trip frequency (PA)</td>
<td>-0.26</td>
<td>0.14</td>
<td>0.07</td>
<td>0.77</td>
<td>0.58 - 1.02</td>
</tr>
<tr>
<td>Recreation trip frequency (PA)</td>
<td>-0.65</td>
<td>0.37</td>
<td>0.08</td>
<td>0.52</td>
<td>0.25 - 1.09</td>
</tr>
<tr>
<td>Duration of MVPA</td>
<td>-0.10</td>
<td>0.05</td>
<td>0.03</td>
<td>0.91</td>
<td>0.83 - 0.99</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.93</td>
<td>1.20</td>
<td>0.44</td>
<td>0.40</td>
<td>--- **</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Summary Statistics</th>
<th>Conventional Suburban</th>
<th>New urbanist</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>159</td>
<td>165</td>
</tr>
<tr>
<td>Chi-square (Model)</td>
<td>26.95</td>
<td>32.74</td>
</tr>
<tr>
<td>Model Significance</td>
<td>0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>-2 Log Likelihood</td>
<td>192.41</td>
<td>185.70</td>
</tr>
<tr>
<td>Cox &amp; Snell R Square</td>
<td>0.16</td>
<td>0.18</td>
</tr>
<tr>
<td>Nagelkerke R Square</td>
<td>0.21</td>
<td>0.25</td>
</tr>
</tbody>
</table>

* p < 0.10
** p < 0.05
***p < 0.01

The significant association between utilitarian physical activity trips and lower BMI by neighborhood necessitated conducting an analysis to determine if the utilitarian physical activity trips made by new urbanist household heads occurred inside or outside their neighborhood. Ascertaining the location of these utilitarian trips would provide a greater understanding of the relationship between neighborhood type and walking or biking trips, which in turn influences...
body weight. Of the total utilitarian physical activity trips made by new urbanist household heads, approximately 1.6 times (.47/.29; \( p = 0.003 \)) more of these trips occurred inside the neighborhood than outside (Table 10).

<table>
<thead>
<tr>
<th>Table 10. Average number of utilitarian physical activity trips by location and neighborhood type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>New urbanist head of household (n = 165)</strong>^a</td>
</tr>
<tr>
<td>Utilitarian trip frequency (PA)</td>
</tr>
<tr>
<td>0.28</td>
</tr>
</tbody>
</table>

^a n = 165 (117 new-urbanist single-family, 48 new-urbanist multi-family) when comparing external versus internal neighborhood utilitarian physical activity trip frequency for new urbanist heads of household.

<table>
<thead>
<tr>
<th>Conventional suburban neighborhoods (n = 159)</th>
<th>New urbanist neighborhood (n = 165)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In neighborhood utilitarian trip frequency (PA)^b</td>
<td>Mean</td>
</tr>
<tr>
<td>0.04</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*b p < 0.10

** p < 0.05

***p < 0.01

The same level of significance was achieved when testing for mean differences using the larger sample (n = 382).

An additional test was conducted to determine if the number of in-neighborhood utilitarian physical activity trips made by heads of household differed between the conventional suburban and the new urbanist neighborhoods. Table 10 shows that new urbanist residents made almost 12 times (.47/.04; \( p = 0.000 \)) as many in-neighborhood utilitarian trips by foot or bike than their counterparts in the conventional suburban neighborhoods.

5. Discussion

While previous studies have examined the relationships between physical activity, weight status and neighborhood characteristics, to date no study has used a new urbanist neighborhood to examine the association between neighborhood design and body weight. This research study compared household heads of a new urbanist neighborhood to household heads of the conventional suburban neighborhoods to determine if new urbanism, as embodied by the case neighborhood, was associated with BMI and weight status. The results of the analysis provide evidence supporting one of the four study hypotheses.

The two primary hypotheses that the household heads of single-family and multi-family dwellings in a new urbanist neighborhood have a lower BMI and are less likely to be overweight or obese than household heads in conventional suburban neighborhoods were not supported by the paper’s findings. For both BMI and prevalence of overweight or obese household heads, no significant difference between neighborhood or dwelling types was found after controlling for age, sex, household size, automobiles per household and education. Notably, based on the BMI values reported, the average household head in both neighborhood and dwelling types was
considered normal weight (BMI between 18.5 and 24.9). The BMI averages for these household heads were generally lower than the BMI values reported in a similar study of high- and low-walkability neighborhoods (Saelens, Sallis, Black et al., 2003), and lower than the BMI values for all but one demographic group in a recent regional study (L.D. Frank et al., 2004). Similarly, the prevalence of household heads in both neighborhood and dwelling types classified as normal weight was higher than North Carolina (41.2%) and national averages (40.9%) for 2001 (National Center for Chronic Disease Prevention and Health Promotion). Also, the prevalence of heads of household classified as obese (n = 22) was considerably lower than the prevalence of obesity found in North Carolina (24.0%) and nationally (22.9%) in 2003. (National Center for Chronic Disease Prevention and Health Promotion).

Due to the influence of physical activity on body weight (Keim, Blanton, & Kretsch, 2004), the lack of difference in BMI and weight status between the household heads in the neighborhoods may be partially explained by the amount of physical activity obtained by the participants in each neighborhood type, which was addressed by the third hypothesis. The average amount of time household heads was engaged in weekly moderate and vigorous physical activity (MVPA) exceeded 4.5 hours for both neighborhood and dwelling types. These levels of activity in each neighborhood led to no detectable significant difference in physical activity levels between the neighborhood and dwelling types. Over half the household heads in both neighborhood and dwelling types achieved sufficient levels of weekly physical activity to meet current recommendations, which was greater than the percentages reported for adults in the North Carolina (37.7%) and the U.S. (47.2) as a whole for 2003 (National Center for Chronic Disease Prevention and Health Promotion). Not surprisingly, the regression models suggest that the number of hours per week engaged in MVPA was associated with a reduction in BMI for both neighborhood types and a 9.0% reduction in the odds of being overweight or obese for new urbanist household heads.

The similarity in physical activity levels between neighborhoods may be largely explained by the study’s research design controlling for significant socio-economic differences between the neighborhood types, as increased socio-economic status in the U.S. tends to be a predictor of healthier lifestyles (Kim, Symons, & Popkin, 2004; Robert & Reither, 2004). With the reported median yearly income for households in this study exceeding $100,000\textsuperscript{5}, the income effect may explain results that diverge from other studies and limit the generalizability of this paper’s results.

The evidence regarding non-motorized travel supports the paper’s fourth hypothesis that the new urbanist heads of household make more non-motorized trips than household heads of the conventional suburban neighborhoods. Specifically, the number of utilitarian physical activity trips were significantly greater for both dwelling types in the new urbanist neighborhood compared to the conventional suburban neighborhoods and 62% of these utilitarian physical activity trips taken by the new urbanist participants were conducted within their neighborhood. Results from the OLS regression models not only corroborated that utilitarian physical activity trip frequency was related to the new urbanist neighborhood, but they also confirmed that these

\textsuperscript{5} The annual median household income was $104,910 for the 289 household heads that reported income (n = 382). The median income was used for descriptive purposes only and was not considered in the analysis as the number of non-responses to this question was extremely high.
trips were significantly associated with reduced BMI for new urbanist heads of households. The number of physical activity trips made for recreation or leisure did not differ between neighborhood and dwelling types, and these trips did not appear to influence the BMI of household heads in either neighborhood type, nor did it significantly decrease the likelihood of being overweight or obese for either group. Overall, the difference in utilitarian physical activity trip frequency and the lack of difference in recreational trip frequency between the two neighborhoods was consistent with a trend of more utilitarian physical activity trips and the same number of recreation trips occurring in high- versus low walkability neighborhood environments (S Handy, 1992; S. Handy, 1996; S. Handy & Clifton, 2001; Saelens, Sallis, & Frank, 2003). The number of trips made by motor vehicle was lower for household heads living in the new urbanist neighborhood compared to household heads living in the conventional suburban neighborhoods. This finding is consistent with previous studies, which report lower automobile usage in more traditional neighborhoods than conventional suburban neighborhoods (Cervero & Gorham, 1995; Cervero & Radisch, 1995; Friedman, Gordon, & Peers, 1994; Holtzclaw, 1994).

In light of the results depicting differences in utilitarian physical activity trip frequency between neighborhood types as reported on the one-day travel diary, the failure to detect a difference in physical activity levels may be the result of utilitarian physical activity trips being greater in number but shorter in duration as a result of reduced trip length (L. Frank & Pivo, 1995) (Dill, 2004). For instance, by virtue of neighborhood design, a new urbanist resident may make three 10-minute walking trips and a conventional neighborhood resident may make one 30-minute walking trip; the total duration is identical, but the trip frequency is not. Although trip duration was not examined in this paper, the finding that trip frequency differed, coupled with similar levels of physical activity, may suggest that people have a time budget for physical activity where time spent walking or bicycling for utilitarian trip purposes occurs at the expense of physical activity elsewhere. An example of this might be household heads in a new urbanist neighborhood substituting utilitarian physical activity trips for recreational trips or conversely, the household heads of a conventional suburban neighborhood expending their physical activity time budget at the gym, which results in insufficient time to devote to utilitarian or recreational physical activity trip making. Future research is needed to better understand the relationship between the frequency of physical activity trips and the duration of those trips.

Regression modeling used in this paper allowed for the detection of potentially spurious effects that result from comparing the mean values for different variables. These models provided evidence supporting several of the early findings of this paper while nullifying others. For instance, the difference between the two neighborhood types regarding the average number of physical activity utilitarian trips, as shown earlier in Table 4, was maintained after other variables were considered. Similarly, the average BMI for heads of households in new urbanist multi-family dwellings was significantly lower than the BMI for household heads in the conventional suburban neighborhoods according to the results of the $t$-test shown earlier in Table 3. However, when other variables were considered, the difference in BMI stopped being significant. The regression models also helped provide a clearer picture as to what variables influenced BMI and the odds of being overweight or obese.

Somewhat surprisingly, the new urbanism design characteristics as embodied by the new urbanist single-family dwelling and multi-family dwellings were not significantly associated
with BMI or the odds of being overweight or obese when the socio-demographic, travel behavior and physical activity variables were included in the regression models. This seems to suggest that there are other paths of influence and factors associated with BMI and weight status than those embodied by the new urbanist neighborhood design.

Limitations and Strengths
This study has several limitations to note. The study’s cross-sectional design allows the relationships identified between variables to be interpreted as associations only, and cannot be interpreted as causal since the information collected is from a single point in time (i.e., the criterion of temporality between an independent variable and dependent variable needed to show causation is not met). The low response rate (25%) to the survey used for this paper could have led to potential non-response error, although the mailed survey response rate was similar to those from other neighborhood and transportation surveys (S. Handy & Clifton, 2001; Kitamura, Laidet, & Mokhtarian, 1997; Saelens, Sallis, Black et al., 2003). Using a binary variable (new urbanist or conventional suburban neighborhood) to capture the neighborhood characteristics does not allow for examining the effects individual micro-level characteristics, such as sidewalks, street furniture, litter and topography, have on differences in travel and physical activity behaviors.

The use of BMI and the reliance on self-reports of height, weight, physical activity and travel behavior through survey are another potential limitation. BMI may overestimate body fat in athletes and those with muscular builds and may underestimate body fat in older persons and those with loss of muscle mass. However, BMI is considered one of the best tools for overweight and obesity assessments in the general population of adult men and women (National Center for Chronic Disease Prevention and Health Promotion, 2005; L. National Heart, and Blood Institute, 2005). Recognizing that measured height and weight would be preferred to the self-report of data for calculating BMI, objectively obtaining these data is not always feasible due to limited resources. For large studies, the accuracy of self-reported height and weight measures to ascertain BMI could be strengthened by obtaining these measurements in a representative sample of the study population (Spencer et al., 2002).

Participant travel behavior was captured using questions modified from the National Household Transportation Survey (NHTS). While the NHTS questionnaire and travel diary were developed through a multi-stage quality control process (Liss, 2005), future research is needed to establish the instrument’s validity and reliability. For this study, the travel diary served to aid recall of daily activity, although the use of a one-day travel diary may not sufficiently reflect habitual trip making behavior among participants. Additionally, the travel diary was to be completed by all household members age 15 years and above. Because household heads were the only participants asked to complete both the survey questions and diary, only their data was analyzed in this paper. Only using heads of household travel diary information potentially introduces bias into the study, as the travel and physical activity patterns of household heads may be dissimilar to other members in the household. This myopic view limits the generalizability of the findings. Ideally, every member of the household regardless of age should have completed both sections of the survey, but it was determined that this would have been too burdensome for participants and the additional requests would negatively impact the response rate. The inclusion of multi-family dwellings may result in differences in behaviors and weight related outcomes since the
heads of household of these apartments and townhouses tend to have different demographics than residents in single-family dwellings. Lastly, the influences that personal diet and access to healthy foods have on body weight were not examined in this study.

This study has several strengths to underscore. By using neighborhoods matched on assessed home value, similar regional accessibility, comparable age of neighborhood and geographic location, the study was able to control for several factors that may potentially confounded the results. While restricting the study sites to a specific area limits the generalizability of this study, the new urbanist and conventional neighborhoods could be considered prototypical of neighborhoods across the nation, and more specifically in the U.S. Southeast (D. A. Rodriguez et al., In press). This study employed a survey tool that combined questions from the prevailing data collection instruments in public health surveillance and transportation planning. The survey tool has a multidisciplinary appeal that allows for a broader understanding of people’s complex travel and physical activity behaviors. Additionally, by utilizing a set of standard and commonly asked questions, this paper’s findings can be compared with other studies.

Future Research
Making more in-neighborhood utilitarian trips by walking or biking indicates that new urbanist household heads spend time circulating through their neighborhood, which possibly contribute to a greater sense of community, perceived neighborhood safety and social cohesion among it residents (B. B. Brown & Cropper, 2001). The association between in-neighborhood utilitarian physical activity trip frequency and a reduction in BMI has relevance for public health professionals, particularly when working with economically disadvantaged populations. Groups with lower incomes report spending less time engaged in leisure time physical activity than higher income groups (Pate et al., 1995). For these groups, the utilitarian travel facilitated by the new urbanist neighborhood design provides an opportunity to integrate physical activity trips into one’s routine. The extent to which the neighborhood environments cause an increase in the time an individual spends being physically active rather than that individual substituting the physical activity time elsewhere in their life is a question for future research, particularly among low income populations. Future studies in this area should also consider using a longitudinal study design in order better assess the causal relationships existing between people’s weight, physical activity patterns, travel behaviors and neighborhood environments.

This study addressed only a few facets of the complex way in which the neighborhood environment is related to weight status. Additional research on the influence neighborhood design has on health is needed to further tease apart which attributes of the built environment facilitate and hinder physical activity and impact health. The methods, results, strengths and limitations present in this study can be used to inform future research in this area of study

6. Conclusion
This study adds to the existing literature by comparing body mass and weight status of household heads in a new urbanist neighborhood with household heads in conventional suburban neighborhoods, which to the author’s knowledge had not been done previously. While no differences were found in overweight and obese prevalence or BMI between the household heads of the two neighborhood types, the encouraging results were the association between...
neighborhood type and utilitarian physical activity trip frequency and the relationship of these trips with BMI. The new urbanist household heads made significantly more in-neighborhood utilitarian trips by non-motorized modes than household head of the conventional suburban neighborhoods. From a transportation and land use planning perspective this echoes the increasingly common message that bringing origins and destinations closer together, as exemplified by the new urbanist neighborhood, makes walking and bicycling realistic mode choices that people can and do use for conducting utilitarian trips.

In summary, this study provided mixed evidence regarding the associations between neighborhood type and body mass, physical activity and travel behaviors. No significant differences in BMI, overweight and obese prevalence, and physical activity levels were detected between household heads in the both new urbanist neighborhood dwelling types and the conventional suburban neighborhoods. However, the study found that new urbanist heads of household made more in-neighborhood utilitarian trips by walking or bicycling than their conventional suburban counterparts and these physical activity trips were related to a reduction in BMI. The relationship found between the neighborhood type and transportation choices impacts physical activity and ultimately, health. As the number of overweight and obese people in the population continues to rise, policy makers, practitioners and researchers in planning, public health and other disciplines should continue attempting to counter this trend by offering environments conducive to physical activity. Neighborhood design, like those typified by new urbanist neighborhoods, may contribute to the solution.
7. Appendices

Appendix A. Survey instrument and travel diary used in this study.

SECTION ONE (ONE COPY):

TO BE FILLED OUT BY THE HEAD OF HOUSEHOLD ONLY
SECTION ONE – ALL RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL.

QUESTIONS ABOUT YOUR HOUSEHOLD (TO BE FILLED OUT BY THE HEAD OF HOUSEHOLD ONLY)

1. What type of home do you currently live in?
   a. Detached single house
   b. Duplex
   c. Townhouse or rowhouse
   d. Apartment
   e. Condominium
   f. Other [Specify] ___________
   g. Don’t know

2. Before moving here, in what type of home did you live in?
   a. Detached single house
   b. Duplex
   c. Townhouse or rowhouse
   d. Apartment
   e. Condominium
   f. Other [Specify] ___________
   g. Don’t know

3. Do you rent or own your current home?
   a. Own
   b. Rent
   c. Other [Specify] ___________
   d. Don’t know

4. What date did you move into your current neighborhood?
   a. _______ Year  b. _______ Month

5. Please list the type and year of each motor vehicle in your household, for Model use the list codes provided below [Include leased, vanpool, or company-owned motorized vehicles if they are used by household members on a regular basis]
   Vehicle #1: ___ Model _______ Year
   Vehicle #2: ___ Model _______ Year
   Vehicle #3: ___ Model _______ Year
   Vehicle #4: ___ Model _______ Year
   Vehicle #5: ___ Model _______ Year

   Codes for Model
   A. sedan/hatchback/convertible/station wagon/coupe
   B. van [mini, cargo, passenger, conversion]
   C. sports utility vehicle [explorer, land rover, jeep, etc.]
   D. pickup truck
   E. other truck
   F. rv [recreational vehicle]
   G. motorcycle
   H. other

6. Please list the first name, age, and sex of each member of your household including yourself. If the member is a school-aged child (age 5 to 18), please mark how the child gets to school. Please use fictitious names or initials if you would like. [Please do not include anyone who usually lives somewhere else or is just visiting, if there are more than six people living in your home, please list them and their information on the previous sheet]

   Your First Name: __________________ Age:_____
   Licensed Driver?   Yes   No
   Sex:   Male   Female

   First Name: __________________ Age:_____
   Licensed Driver?   Yes   No
   Sex:   Male   Female

   If school-age, he/she travels to school by:
   a. Walk  b. Car ride or drives to school
   e. Bicycle  c. Transit (bus or school bus)
   f. Other [Specify] ___________

   First Name: __________________ Age:_____
   Licensed Driver?   Yes   No
   Sex:   Male   Female

   If school-age, he/she travels to school by:
   a. Walk  b. Car ride or drives to school
   e. Bicycle  c. Transit (bus or school bus)
   f. Other [Specify] ___________

   First Name: __________________ Age:_____
   Licensed Driver?   Yes   No
   Sex:   Male   Female

   If school-age, he/she travels to school by:
   a. Walk  b. Car ride or drives to school
   e. Bicycle  c. Transit (bus or school bus)
   f. Other [Specify] ___________

   First Name: __________________ Age:_____
ONE TRIP IS CONSIDERED ANY ONE-WAY TRIP OVER 300 FEET. ALL RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL.

1. What best describes your employment status? 
   [Please check only one and answer the following questions accordingly]
   a. Work full-time outside the home
   b. Work part-time outside the home
   c. Student  → Please skip to Question 2
   d. Work full-time at home
   e. Work part-time at home
   f. Unemployed (non-student)
   g. Retired
   h. Other [Specify]__________________
   } → Please skip to Question 6

2. What best describes your occupation?
   a. Clerical/Secretary
   b. Service
   c. Production/Manufacturing
   d. Executive/Managerial
   e. Skilled Trades
   f. Retired
   g. Sales/Retail
   h. Computer/Technical
   i. Medical/Health
   j. Other [Specify]__________________

3. Do you ever telecommute/telework to work? If so, how many times per week?
   a. No  b. Yes, times per week _____

4. How much time does it typically take to travel to work or to school? [one-way travel]
   a. _____ hours  b. _____ minutes

5. How much do you typically spend on traveling to work or to school per week? [Include all gas, parking, or transit fares]
   $_______

6. About how many miles per week do you travel by car?
   _______ miles

7. In a typical week, Monday through Friday, how often do you make the following one-way trips:

   | Drive to work or school by car | 0 times | 1 | 2 | 3 | 4 | 5 | 6 | 7+
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<td>Go out for recreation, entertainment, or meals (watch/play sports, movie, museum, restaurant/bar, visit friends/relatives)</td>
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On a scale of 1 to 5, express your level of agreement with the following statements. 1 = strongly disagree.... 5= strongly agree  [Circle a number for each statement]

1. I like the flexibility that driving allows
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

2. I enjoy walking
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

3. I am comfortable riding a bus
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

4. I would like to have more time for leisure
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

5. We should raise the price of gasoline to reduce congestion and air pollution
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

6. It’s important for children to have a large backyard for playing
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

7. Sidewalks make walking easier in my neighborhood
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

8. Environmental protection is an important issue
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

9. I enjoy a house close to the sidewalk so that I can see and interact with passersby
   - 1 strongly disagree
   - 2 neutral
   - 3 strongly agree

10. Too much land is consumed for new housing, stores, and offices
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

11. I enjoy bicycling
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

12. I can be comfortable living in close proximity to my neighbors
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

13. Hills or other barriers in my neighborhood make walking/bicycling difficult
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

14. My neighborhood seems safe for walking or bicycling
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

15. Sitting in traffic aggravates me
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

16. I prefer a lot of space between my home and the street
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

17. Taking public transit is inconvenient
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

18. Too many people drive alone
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

19. Children should have a large public play space within safe walking distance of their home
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

20. Having shops and services close by is important to me
    - 1 strongly disagree
    - 2 neutral
    - 3 strongly agree

21. My ideal commuting time to work or school is:
    ___Less than 5 minutes
    ___Between 5 and 15 minutes
    ___Between 15 and 30 minutes
    ___More than 30 minutes

22. The longest acceptable time for me to commute to work or school is:
    ___Less than 5 minutes
    ___Between 5 and 15 minutes
    ___Between 15 and 30 minutes
    ___Between 30 and 45 minutes
    ___Between 45 and 1 hour
    ___More than 1 hour
1. In a usual week, do you walk for at least 10 minutes at a time for recreation or exercise?
   No __ {skip to Question 5} Yes ___

2. How many days per week do you walk for at least 10 minutes at a time? ______

3. On days when you walk for at least 10 minutes at a time, how much total time per day do you spend walking?
   a ___ hours  b ___ minutes

4. Where does your walking activity for recreation and exercise take place?
   a Always in my neighborhood
   b Mostly in my neighborhood
   c Sometimes in my neighborhood and sometimes elsewhere
   d Mostly away from my neighborhood
   e Always away from my neighborhood

**Now consider moderate and vigorous physical activities. Moderate activities cause small increases in breathing or heart rate, while vigorous activities cause large increases in breathing or heart rate.**

5. In a usual week, do you do MODERATE physical activities for at least 10 minutes at a time, such as brisk walks, bicycling, vacuuming, gardening, or anything else that causes SMALL INCREASES in breathing or heart rate?
   No __ {skip to Question 9} Yes ___

6. How many days per week do you do these moderate activities for at least 10 minutes at a time? ______

7. On days when you do moderate activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?
   a ___ hours  b ___ minutes

8. What percentage of the total time that you spend on moderate activities do you spend:
   ___% At home
   ___% Outside of my home but in my neighborhood
   ___% Outside of my neighborhood
   = 100% TOTAL

**Now consider vigorous activities that cause large increases in breathing or heart rate such as jogging, swimming, or aerobics.**

9. In a usual week, do you do VIGOROUS physical activities for at least 10 minutes at a time, such as running, aerobics, heavy yard work, or anything else that causes LARGE INCREASES in breathing or heart rate?
   No __ {skip to Question 13} Yes ___

10. How many days per week do you do these vigorous activities for at least 10 minutes at a time? ______

11. On days when you do vigorous activities for at least 10 minutes at a time, how much total time per day do you spend doing these activities?
    a ___ hours  b ___ minutes

12. What percentage of the total time that you spend on vigorous activities do you spend:
    ___% At home
    ___% Outside of my home but in my neighborhood
    ___% Outside of my neighborhood
    = 100% TOTAL

13. What is your weight? _______ pounds

14. What is your height _______ feet _______ inches

15. How often have you used the Internet in the past 6 months at home?
    a Everyday
    b Almost everyday
    c Once a week
    d Once a month
    e Never

16. What is the highest level of education you have completed?
    a Less than High School
    b High School or GED
    c Vocational/Technical Degree
    d Some College or Associate’s Degree
    e Bachelor’s Degree (BA,BS)
    f Some graduate school, no degree
    g Graduate or Professional School

17. If you work, what is your approximate household income before taxes (information is strictly confidential)?
    a Under $20,000
    b $20,000–$30,000
    c $30,001–$40,000
    d $40,001–$50,000
    e $50,001–$60,000
    f $60,001–$80,000
    g $80,001–$100,000
    h $100,001–$150,000
    i $150,001–$200,000
    j Over $200,000
SECTION TWO (FIVE COPIES):

THIS SECTION IS TO BE FILLED OUT SEPARATELY BY EACH HOUSEHOLD MEMBER OVER THE AGE OF 15.

PLEASE DISTRIBUTE EACH IDENTICAL COPY TO EACH HOUSEHOLD MEMBER OVER THE AGE OF 15.

PLEASE FILL-IN THE DATE IN THE TOP RIGHT-HAND SPACE PROVIDED ON THE NEXT PAGE.

PLEASE FILL-IN THE RESPONDENT’S NAME IN THE TOP LEFT-HAND SPACE PROVIDED ON THE NEXT PAGE.

PLEASE USE THE SAME NAME YOUR HEAD OF HOUSEHOLD PROVIDED IN SECTION 1.

ALL RESPONSES WILL BE KEPT STRICTLY CONFIDENTIAL.
Instructions for completing your Travel Diary

- Use the diary on the back side of this page to record trips on your travel day and please record this date in the upper right hand corner of the page.
- Please fill-in your name, or the appropriate name your head of household provided in Section 1, in the top left-hand space provided on the back side of this page.
- The travel day starts at 4:00 a.m. and ends at 4:00 a.m. the next day.
- A trip is whenever you travel from one place to another. Use one line to record each trip. Include:
  - All trips you made for a specific reason, such as to go to work or school, buy gas, or drop someone off.
  - Return trips, such as coming home from work or school.
  - Walks, jogs, bike rides, and short drives. If you started and ended in the same place, list the farthest point you reached and record a return trip.
  - Trips of more than 300 feet. These include walking for exercise, walking dogs, bike rides, etc.
  - Do not include stops just to change the type of transportation.
- If you made more than ten trips as part of your job (examples: a cab driver, delivery person, police officer):
  - Don’t record the trips that were made as part of your job.
  - Do record the trips that got you to and from your work place.
  - Do record all other trips that were not part of your job.
- If you made more trips than will fit on the diary, record the rest on a blank sheet of paper.
- Estimate the costs of your travel to the best of your ability. Costs for taking the bus should only include bus fare. Costs for driving should only include parking. Costs for driving should not include gas, wear and tear, and ownership fees (such as insurance and depreciation) for the vehicle.

Example of Trips on a Travel Day

<table>
<thead>
<tr>
<th>WHERE did you go?</th>
<th>WHERE is it located? (List major cross streets)</th>
<th>What TIME did you start and end each trip?</th>
<th>WHY did you go there?</th>
<th>HOW did you travel?</th>
<th>HOW FAR was it? (blocks or miles)</th>
<th>COSTS associated with travel (parking &amp; transit fare only)</th>
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</thead>
<tbody>
<tr>
<td>1. Wilson's Pharmacy</td>
<td>North St/Bryant Rd</td>
<td>Started at: 8:15am</td>
<td>Arrived at: 8:25am</td>
<td>Pick up medication</td>
<td>Drive</td>
<td>1/2 mile</td>
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<td>2. St. Mary's Hospital</td>
<td>Park St. / Highway 101</td>
<td>Started at: 8:35am</td>
<td>Arrived at: 8:50am</td>
<td>Work</td>
<td>Drive</td>
<td>4 miles</td>
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<td>3. Home</td>
<td></td>
<td>Started at: 4:50pm</td>
<td>Arrived at: 5:05pm</td>
<td>End of workday</td>
<td>Drive</td>
<td>4 miles</td>
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<td>4. Jackie's Bakery</td>
<td>High St. / 8th Ave.</td>
<td>Started at: 5:15pm</td>
<td>Arrived at: 5:30pm</td>
<td>Get some bread</td>
<td>Walk</td>
<td>3 blocks</td>
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<td>5. Home</td>
<td></td>
<td>Started at: 5:45pm</td>
<td>Arrived at: 6:00pm</td>
<td>Rest</td>
<td>Walk</td>
<td>3 blocks</td>
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<td>6. A jog</td>
<td>Loop around bikepath</td>
<td>Started at: 6:30pm</td>
<td>Arrived at: 7:00pm</td>
<td>Exercise</td>
<td>Jogged</td>
<td>3 miles</td>
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<td>WHERE did you go?</td>
<td>WHERE is it located?</td>
<td>What TIME did you start and end each trip?</td>
<td>WHY did you go there?</td>
<td>HOW did you travel?</td>
<td>How FAR was it?</td>
<td>COSTS associated with travel</td>
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<td>(Name of place)</td>
<td>(List major cross streets)</td>
<td>Started at: Arrived at:</td>
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<td>(List route if using bus)</td>
<td>(blocks or miles)</td>
<td>(parking &amp; transit fare only)</td>
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8. References


Giles-Corti, B., & Donovan, R. J. (2002). Socioeconomic status differences in recreational physical activity levels and real and perceived access to a supportive physical environment. Prev Med, 35(6), 601-611.


Sturm, R. (2002). The effects of obesity, smoking, and drinking on medical problems and costs. Obesity outranks both smoking and drinking in its deleterious effects on health and health costs. Health Aff (Millwood), 21(2), 245-253.


World Health Organization.