An Examination of Walkability in the Las Vegas Metropolitan Area

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AN EXAMINATION OF WALKABILITY IN THE
LAS VEGAS METROPOLITAN AREA

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Abstract

Introduction: The benefits to regular physical activity are well established. Walkability is one element of the built environment that has been correlated with increased levels of physical activity. The auto-centric design of Las Vegas Metropolitan area (LVMA) is unique in ways that may influence walkability. The purpose of this study was to determine which urban design characteristics are associated with walking and physical activity in moderate income neighborhoods in LVMA. Methods: The standard walkability measure developed by Frank et al. (2010) was used to calculate the walkability index of seven neighborhoods. Residents of the two most walkable and two least walkable neighborhoods were then surveyed on their walking and physical activity levels and perceptions of neighborhood design characteristics as barriers to walking. Logistic regression was used to determine what factors predicted meeting the recommended amount of physical activity. Results: A total of 147 survey responses were collected. A large percentage of residents agree that lack of shade, poor land use mix, and poor street connectivity is a barrier to walking for active transport and leisure. There were significant differences between neighborhoods in percentage of respondents agreeing that long distances between crosswalks and high speed streets were a barrier to walking for active transport and leisure. Logistic regression revealed that perceptions of the urban design characteristics in neither the standard walkability index, nor the index which included design characteristics unique to LVMA significantly predicted meeting the physical activity recommendations. Discussion: Results suggest that the auto-centric design of LVMA may be so unique that those factors which have been associated with walking in previous studies are not associated with walking in LVMA. Further analysis of both physical and social factors relating to walkability is necessary to determine what actions are needed to increase walking and physical activity in LVMA.
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Chapter 1

Introduction

The link between physical activity and health is well established. Participating in regular physical activity improves overall health, controls weight, reduces the risk of chronic disease, and improves psychological well-being. Physical inactivity is a major public health concern, as it is correlated with increased morbidity and mortality (Centers for Disease Control and Prevention, 2012). Despite this, only 52% of adults met the aerobic physical activity requirements of 150 minutes per week in 2011, and 24% of adults reported that they had engaged in no physical activity at all within the last month (Centers for Disease Control and Prevention (CDC), 2011a; Centers for Disease Control and Prevention (CDC), 2011a; Centers for Disease Control and Prevention, 2010). This falling rate of physical activity, coupled with an obesity promoting environment have resulted in an estimated 73% of the U.S. adult population (Ogden & Carroll, 2010) and 31% of the youth population being overweight or obese (Ogden, Carroll, Kit, & Flegal, 2012).

Until recently public health interventions have been aimed at individual-level characteristics such as eating habits and physical activity levels. This approach tends to put blame on the victim, rather than a changing environment and failing public policies which create obesity promoting environments. Fortunately, the focus is shifting from individual responsibility to a more ecological approach in which obesity is seen as a combination of the physical and social environment, behavior, and genetics (Lang & Rayner, 2007). This paradigm shift has led to an explosion of research aiming to identify environmental variables that correlate with good health. The built environment, or environmental features that are man-made, have emerged as an important influence on physical activity and obesity rates, as it incorporates both physical and social elements of the community (Papas et al, 2007).
Physical activity can be classified into two types, recreational and utilitarian. Recreational physical activity is done purposefully, to obtain exercise. It is a conscious decision and requires a high level of commitment. For this reason it is often hard for individuals to maintain patterns of recreational physical activity (Frumkin, Frank, & Jackson, 2004a). Utilitarian physical activity consists of physical activity that takes places incidentally while the individual accomplishes another purpose (L. D. Frank, Engelke, & Schmid, 2003a). This is also referred to as physically active travel or active transport. Incorporating physical activity into one’s daily life may prove a less complicated and a more successful strategy. Improving the built environment to make it convenient and easy for people to be physically active and partake in more active transport is one way to increase rates of physical activity. Promoting active transport is dually beneficial; it not only improves health outcomes but also is a more sustainable form of transportation.

Public health literature has identified walking as not only the most common form of physical activity, but also the most amenable to influence (Owen, Humpel, Leslie, Bauman, & Sallis, 2004). It is an activity that can be performed most anywhere and does not involve any special skills or equipment. Walking may be a key component to attaining the recommended amount of physical activity.

Walkability, or how conducive an area is to walking and the activities of daily life, can influence physical activity levels directly (Bauman, Sallis, & Owen, 2002). Numerous studies have shown that individuals who reside in a walkable neighborhood get more overall minutes of physical activity (Berke, Gottlieb, Moudon, & Larson, 2007; L. D. Frank, Schmid, Sallis, Chapman, & Saelens, 2005; King et al., 2006; B. E. Saelens, Sallis, & Frank, 2003; Sallis et al., 2009; Van Dyck et al., 2010) and more minutes of active transport each week (B. E. Saelens et al., 2003; Van Dyck et al., 2010). Frank et al. (2006) reported that at least five studies found walkable
neighborhoods to be negatively correlated with obesity rates and BMI (Doyle, Kelly-Schwartz, Schlossberg, & Stockard, 2006; L. Frank et al., 2006; Sallis et al., 2009; Van Dyck et al., 2010). More walkable neighborhoods have been correlated with less time spent in a vehicle (Frank et al., 2006). Conversely, more time spent in a vehicle is correlated with fewer minutes of physical activity (L. D. Frank, Andresen, & Schmid, 2004), and increased risks of obesity (Lopez-Zetina et al., 2005; Frank et al., 2004). Thus, walkable neighborhoods result in less time spent in a vehicle, more physical activity, and lower BMIs. It is imperative that public health interventions that focus on removing barriers to walking be implemented in order to foster sustainable, healthy communities.

Walkability has been measured in various ways. Studies examining the built environment have identified numerous correlates of walking including accessibility based on distance, mixed land use, density, aesthetics, sidewalk availability, street connectivity, safety, age of the neighborhood, and a general composite measure of neighborhood walkability (B. Saelens & Handy, 2008). Some studies have focused on perceived walkability and used survey methodology to determine influencing factors, while others have used objective measures such as Geographic Information Systems (GIS) and field audits. It is evidenced that perceived walkability is correlated with objective measures of walkability, demonstrating that residents are able to accurately gauge if their neighborhood is walkable. The most widely used measure of walkability was developed by Frank and colleagues and measures four components: net residential density, intersection density, land use mix, and retail floor area ratio (L. Frank et al., 2010). With so many environmental correlates of walking, however, it can be difficult to encompass all factors which may influence walkability.

It is consistently evidenced in the literature that the built environment influences physical activity. However, the design of the built environment has changed considerably over
the last century. Before the automobile cities were designed to accommodate walking as the main form of transportation, however, cities which developed after the boom of the automobile were designed to accommodate vehicles (Frumkin, Frank, & Jackson, 2004b). These design choices have had negative implications on public health including issues of air quality, pedestrian safety and injury, increased chronic medical conditions and decreased health related quality of life, increased sedentary lifestyles, and decreased levels of social capital (Frumkin, 2009).

The Las Vegas Metropolitan Area (LVMA) is a newer, sprawling, western metropolitan area worth studying as it possesses unique and relevant features. It has many unique urban design characteristics that can influence walkability, yet are not captured by the standard, four component, walkability index. The street networks in LVMA developed along a grid pattern which allows for numerous high speed arterial streets creating a very non-pedestrian friendly environment. This design has also resulted in long distances between crosswalks which makes active transport inconvenient and reduces pedestrian safety. LVMA also has numerous gated or single entry communities. The single access point both in and out of the development makes active transport inconvenient by significantly increasing trip distance. One urban design characteristic of particular importance in LVMA is the use of shade trees to minimize the impact of the extreme desert heat. Too few of such trees may make active transport unpleasant. The purpose of this research is to better understand which urban design characteristics are associated with walking in moderate income neighborhoods in LVMA.
Chapter 2

Literature Review

**Physical Activity and Health.**

Physical activity is an essential component of good health. Participating in regular physical activity improves overall health, controls weight, reduces the risk of chronic disease such as heart disease, type II diabetes, and certain types of cancer, and promotes psychological well-being (Centers for Disease Control and Prevention, 2012). Participating in regular physical activity also results in increased bone density and the potential to reduce the risk of fractures and osteoporosis later in life (Warburton, Nicol, & Bredin, 2006). Physical activity has been shown to promote brain health by stimulating neurogenesis, increasing resistance to brain insult, and improving learning and mental performance (Cotmana & Berchtoldb, 2002).

While being physically active promotes good health, physical inactivity is a major public health concern. The World Health Organization (WHO) has identified physical inactivity as the fourth leading risk factor for global mortality; it is responsible for an estimated 3.2 million deaths annually (World Health Organization, 2012). In the United States, poor diet and physical inactivity are the second leading cause of preventable death, responsible for about 400,000 deaths per year (Mokdad, Stroup, & Gerberding, 2004).

Physical inactivity is directly linked to being overweight. An estimated 73% of the U.S. adult population (Ogden & Carroll, 2010) and 31% of the youth population are overweight or obese (Ogden et al., 2012). These figures are disconcerting as obesity is associated with excess morbidity and mortality. Overweight and obesity lead to a plethora of negative health outcomes, including increased risk for cardiovascular disease, type II diabetes, osteoarthritis, stroke, muscular skeletal disorders, respiratory disorders, reproductive health complications, mental health disorders, and several types of cancer including breast, colon, gallbladder,
thyroid, ovarian, prostate, kidney, and cervical (Centers for Disease Control and Prevention, 2011; World Health Organization, 2011). Moreover, overweight youth experience reduced emotional well-being, including negative self-esteem and increased anxiety and depression; they are teased three times more often and are rejected by their peers more when compared to normal weight children (Warschburger, 2005). Obese youth are more likely to become obese adults with the aforementioned health conditions. Such chronic conditions not only shorten the lives of individuals, but also reduce quality of life. Sturm (2002) reported that being obese has nearly the same association with chronic health conditions as does 20 years aging (R. Sturm, 2002).

Although the link between physical activity and health is well established, most Americans do not attain the recommended amounts of physical activity. The Department of Health and Human Services (HHS) released the 2008 Physical Activity Guidelines for Americans, which identify the key guidelines for promoting and maintaining health. The report notes that some physical activity is better than no physical activity, and that health benefits increase as the “amount of physical activity increases through higher intensity, greater frequency, and/or longer duration” (Department of Health and Human Services [HHS], 2008). It is recommended that adults age 18 to 65 participate in 150 minutes per week of moderate intensity aerobic activity with muscle strengthening activities 2 or more days per week; or 75 minutes of vigorous intensity aerobic activity with muscle strengthening activities 2 or more days per week; or an equivalent combination of moderate or vigorous aerobic activity and muscle strengthening activities 2 or more days per week (Department of Health and Human Services [HHS], 2008). The guidelines state that physical activity can be spread throughout the week, so long as it occurs in bouts of 10 minutes or longer (Department of Health and Human Services [HHS], 2008). Recent studies have shown that even bouts less than 10 minutes have similar health
benefits of improved cardiovascular profiles and lower BMI (Glazer et al., 2013). Moderate intensity is defined as an aerobic activity which moderately increases the heart rate, such as a brisk walk or bike ride on level ground (Department of Health and Human Services [HHS], 2008). Vigorous intensity is defined as an aerobic activity which significantly increases heart rate, such as running or swimming laps (Department of Health and Human Services [HHS], 2008). The guidelines for children and adolescents state that they should receive 60 minutes or more of physical activity daily, which includes muscle strengthening activities 3 days per week and bone strengthening activities 3 days per week (Department of Health and Human Services [HHS], 2008).

Data from the 2011 Behavioral Risk Factor Surveillance System (BRFSS) revealed that about 48.4% of adults do not engage in the recommended amount of physical activity, and in 2010 24% of adults reported that they had engaged in no physical activity at all within the last month. Las Vegans are very similar to the national average, with 50.9% of adults not engaging in the recommended amount of physical activity (Centers for Disease Control and Prevention, 2009) and 23.7% participating in no physical activity at all within the last month (Centers for Disease Control and Prevention, 2010). This falling rate of physical activity, coupled with an obesity promoting environment has resulted in a largely sedentary, unhealthy population. Efforts to curtail this epidemic are critical.

Until recently public health interventions were aimed at individual-level characteristics such as eating habits and physical activity levels. This approach tends to put blame on the victim, rather than a changing environment and failing public policies which create obesogenic environments, or obesity promoting environments. Fortunately, the focus is shifting from individual responsibility, to a more ecological approach in which obesity is seen as a combination of the physical and social environment, behavior, and genetics (T. Lang & Rayner,
To fully understand the obesity epidemic, the underlying causes must be examined. What factors influence individual behavior to promote obesity? This paradigm shift has led to an explosion of literature aiming to identify environmental variables which correlate with good health. The built environment has emerged as an important influence of obesity rates, as it incorporates both physical and social elements of the community (Papas et al., 2007).

**Utilitarian versus Recreational Physical Activity**

Physical activity can be classified into two types, recreational or utilitarian. Recreational physical activity is done purposefully, to obtain exercise. An example would be a jog around the park or lifting weights (Frumkin, Frank, & Jackson, 2004a). Recreational physical activity, or exercise, is a conscious decision and requires a high level of commitment; for this reason it is often hard for individuals to maintain patterns of recreational physical activity. The most commonly reported barriers to exercise are lack of time and lack of ability and motivation (L. D. Frank, Engelke, & Schmid, 2003a).

Utilitarian physical activity consists of physical activity that takes places incidentally while the individual accomplishes another purpose (L. D. Frank, Engelke, & Schmid, 2003a). This is also referred to as active transport. An example would be walking to the store or bicycling to school; where the physical activity one gets is secondary to accomplishing another task (L. D. Frank, Engelke, & Schmid, 2003a). Incorporating utilitarian physical activity into one’s daily life may prove a less complicated and a more successful strategy.

Arguments are made that changing the environment to one which promotes physical activity may prove more useful, as it is impractical to expect behavior change when the environment is one that discourages it (L. D. Frank, Engelke, & Schmid, 2003a). The literature supports the claim that those who reside in neighborhoods which support physical activity attain more minutes of physical activity (L. D. Frank, Engelke, & Schmid, 2003a; L. D. Frank et al.,
A number of built environment factors have been identified which influence the amount of active transport. These include density, street connectivity, land use mix, safety, aesthetics, and pedestrian infrastructure (A. Forsyth, Michael Oakes, Lee, & Schmitz, 2009; L. Frank et al., 2006; L. Frank et al., 2010). Public health interventions which focus on modifying the built environment to promote health are essential.

**The Built Environment.**

The built environment encompasses all spaces, buildings, and products that are created by or modified by humans (HHS, 2004). It provides the setting for human activity from where people live, eat, and play, to how they socialize. With regard to physical activity, it can be broken down into three basic components: transportation systems, land use patterns, and urban design characteristics (Frank, Engelke, & Schmid, 2003, CH 6).

Transportation systems are the network of physical infrastructure that carry traffic; street networks, transit systems such as rail or bus, and systems for non-motorized users such as jogging trails or bike paths (Frank, Engelke, & Schmid, 2003, CH 7). Transportation systems provide the structure for a large amount of physical activity and active transport. Unfortunately, the majority of modern U.S. cities and suburbs are single use developments which favor cul-de-sacs rather than through streets, creating an environment which hinders physical activity (Frank, Engelke, & Schmid, 2003, CH 8).
Land use patterns refer to the arrangements of features in the built environment, such as buildings and parks. Terms often associated with land use patterns are density and land use mix. Density, or the level of compactness, refers to the population and employment in a given area. High density neighborhoods reduce the need for a vehicle by locating activities close together. Land use mix refers to the different type of uses in a close proximity such as residential, retail, and commercial use. A high land use mix also reduces the need for a vehicle by increasing accessibility to areas of interest (L. D. Frank, Engelke, & Schmid, 2003b).

Urban design characteristics influence how an individual perceives the built environment, including desirability of walking or participating in physical activity. Characteristics such as streets, trees, lawns, sidewalks, crosswalks, curbs, trashcans, and fences, among others, influence one’s perception of the environment. Site design refers to aesthetics and attractiveness of the street such as the size and attractiveness of buildings, the placement of parking spaces and the design of the space between the buildings (L. D. Frank, Engelke, & Schmid, 2003b). Both street design and site design are important components of the built environment, as individual behaviors are shaped through perceptions that determine engagement in physical activity.

*The built environment and physical activity.*

The built environment plays a critical role in physical activity and can either enhance or hinder opportunities. Physical activity levels have decreased dramatically over the last century due to a number of different factors. These include poor community design which makes walking, biking, and playing outside either inconvenient or dangerous. Changes in land density have located destinations such as employment, retail, and entertainment beyond a reasonable walking distance which makes it inconvenient to partake in active transport. The World Health Organization (WHO) attributes this trend of decreased energy expenditure to sedentary
lifestyles related to motorized transport, physically undemanding leisure activities, and phasing out of physically demanding jobs (World Health Organization, 2011). Environmental changes have led to the creation of built environment which hampers opportunity for physical activity.

These three components of the built environment have each been shown to influence physical activity in some way. Street networks and sidewalks are the most common transportation network, and arguably the most important (Ewing, Handy, Brownson, Clemente, & Winston, 2006; L. D. Frank, Engelke, & Schmid, 2003). One study found that 66.1% of respondents reported neighborhood streets as the most common place they performed physical activity (Brownson, Baker, Housemann, Brennan, & Bacak, 2001). This is where active transport to work, shopping, dining out, and daily activities occur and where walking for exercise frequently takes place (Ewing et al., 2006; Ewing et al., 2006). Street networks determine how well connected destinations are and influence choices on modes of transportation and trip route (Frank, Engelke, & Schmid, 2003, CH 7). A highly connected network would have a high intersection density, or include a large number of intersections, making a direct route of travel possible. Conversely, low connectivity encompasses very few intersections and forces people to travel greater distances to reach their destination (Frank, Engelke, & Schmid, 2003, CH 7).

Figure 1 demonstrates that the more connected street network significantly reduces trip distance and makes non-vehicular travel more convenient. Numerous studies have shown that high street connectivity is associated with increased active transport (L. D. Frank, Kerr, Sallis, Miles, & Chapman, 2008; B. Saelens, Sallis, Black, & Chen, 2003; B. E. Saelens et al., 2003).
Figure 1. A well connected street network with more intersections reduce trip distance and make active travel more convenient. Source: (City of Las Vegas, 2012)

Land use patterns are also a strong determinant in physical activity. Individuals are more likely to participate in active transport or utilize existing facilities so long as it remains convenient. McCormack, Giles-Corti, and Bulsara (2008) found that post boxes, bus stops, convenience stores, news agencies, shopping malls, and transit stations within 400 meters and schools, transit stations, news agencies, convenience stores and shopping malls within 1500 meters were correlated with more minutes of active transport. Additionally, they found a dose-response relationship between land-use mix and active transport, with each additional destination within 400 meters resulting in an additional 12 minutes of active transport per two
week period (McCormack, Giles-Corti, & Bulsara, 2008). Data have shown that residents in communities with high density, high land use mix, and greater street connectivity participate in active transport more frequently (L. Frank et al., 2006; B. E. Saelens et al., 2003). Individuals who live close to a variety of recreational facilities are more physically active overall (Sallis & Glanz, 2009) and those who reside in a community which facilitates physical activity are healthier (Papas et al., 2007).

Urban design characteristics or perceptions of the built environment have been shown to influence physical activity. Several studies have found that individuals are less likely to walk or participate in physical activity if the aesthetics of the environment are unpleasant (Ball, Bauman, Leslie, & Owen, 2001; Frost et al., 2010; Humpel, Owen, & Leslie, 2002; Owen et al., 2004; B. Saelens et al., 2003) or are lacking in safety (Doyle et al., 2006; Foster & Giles-Corti, 2008; Frost et al., 2010; Zhu & Lee, 2008). Safety can be measured in terms of physical or perceived attributes. For example, Addy et al. (2004) found that individuals who reported good street lighting were more likely to be regularly active, Giles-Corti & Donovan (2003) found that individuals who reported experiencing minor traffic were less likely to walk at recommended levels, and King et al. (2006) found that individuals who reported encountering loose dogs were less likely to walk for errands or leisure (Addy et al., 2004; B. Giles-Corti & Donovan, 2003; King et al., 2006). Urban design characteristics such as sidewalk and trail availability are influential in physical activity. Addy et al. (2004) found that sidewalk presence predicted walking 150 minutes or more per week (Addy et al., 2004) and Giles-Corti & Donovan (2002) found that individuals residing in neighborhoods with sidewalks were more likely to participate in active transport. Wilson et al. (2004) found that having and using trails in the neighborhood predicted meeting the physical activity guidelines (B. Giles-Corti & Donovan, 2002; Wilson et al., 2004).
The Community Preventive Service Task Force (Task Force) is an independent body of experts appointed by the director of the Centers for Disease Control and Prevention “to provide evidence-based recommendations about community preventive services, programs, and policies that are effective in saving lives, increasing longevity, and improving Americans’ quality of life.” In a systematic review of the literature examining environmental and policy strategies to promote physical activity, the Task Force concluded that both community-scale and street-scale urban design and land use policies and practices met the criteria for being effective physical activity interventions and should be a public health priority (Heath et al., 2006). Community-scale urban design and land use policies and practices included interventions such as changes to zoning or building codes, policies encouraging transit oriented development, street layouts, and location of stores and jobs within walking distance (Heath et al., 2006). Street-scale urban design policies and practices included interventions such as improved street lighting, enhanced aesthetics, or safety infrastructure such as crosswalks and traffic calming measures (Heath et al., 2006).

Improving the built environment to make it convenient and easy for people to be physically active and partake in more active transport is one way to increase rates of physical activity. Public health research has identified walking as not only the most common form of physical activity, but also the most amenable to change (Owen et al., 2004). It is an activity that can be performed most anywhere and does not involve any special skills or equipment. As such, an emphasis should be placed on designing and promoting a built environment which enhances walkability.

**Walkability.**

Walkability refers to how conducive an area is to walking and the activities of daily life. A walkable neighborhood ensures that individuals have access to a variety of shops and services
which can be conveniently reached through active transport. It is a concept that links the built environment to key aspects of a healthy community. Walkability has numerous benefits for the health of the population and the environment.

The built environment has been found to directly impact walking behaviors (Bauman et al., 2002). Numerous studies have shown that individuals who reside in a walkable neighborhood get more overall minutes of physical activity (Berke et al., 2007; L. D. Frank et al., 2005; King et al., 2006; B. E. Saelens et al., 2003; Sallis et al., 2009; Van Dyck et al., 2010). Frank et al. (2005) found that residents in the most walkable neighborhoods of Atlanta were 2.4 times more likely to attain the recommended amount of physical activity than residents in the least walkable neighborhoods (L. D. Frank et al., 2005). Adams et al. (2011) reported that high walkable neighborhoods differed from other neighborhood types in that residents attained an average of 13 more minutes per day of moderate to vigorous physical activity in Baltimore, MD and as much as 75 more minutes per week of leisure time physical activity in Seattle, WA. Saelens et al. (2003) showed that residents of highly walkable neighborhoods reported more than 70 more minutes of physical activity per week than residents of low walkability neighborhoods. In a study of Belgian adults, high-walkable neighborhoods were associated with 49 more minutes of moderate to vigorous physical activity per week (Van Dyck et al., 2010).

In addition to overall physical activity, individuals living in walkable neighborhoods participate in more minutes of active transport each week. Adams et al. (2011) noted that as walkability increased minutes of active transport increased, with individuals in walkable neighborhoods reporting about 65 more minutes per week compared to non-walkable neighborhoods. Sallis et al. (2009) reported that residents of walkable neighborhoods walked about 31 more minutes per week for transportation compared to low-walkability neighborhoods. Van Dyck et al. (2010) reported that in Ghent, Belgium, living in a high-walkable
neighborhood was associated with 80 more minutes per week of walking for transport. Sallis et
al. (2004) found that residents of high walkable neighborhoods reported two times more
walking trips per week than residents of low walkable neighborhoods (Sallis, Frank, Saelens, &
Kraft, 2004). Frank et al. (2006) found that a 5% increase in walkability was associated with a
32.1% increase in physically active transport.

More walkable neighborhoods have also been correlated with lower BMIs and obesity
rates. In a review of the literature, Frank et al. (2006) reported five studies which found
walkable neighborhoods to be negatively correlated with obesity rates and BMI, an additional
three were found (Doyle et al., 2006; L. Frank et al., 2006; Sallis et al., 2009; Van Dyck et al.,
2010). Frank et al. (2006) showed that a 5% increase in walkability was associated with a 0.23-
point reduction in BMI. Using data from the National Health and Nutrition Examination Survey III
(NHANES III) and Uniform Crime Report (UCR), Doyle et al. (2006) found that individuals that
lived in walkable, safe neighborhoods had lower BMIs than those who did not. A cross-sectional
survey by Brown et al. (2009) showed that more walkable neighborhoods were associated with
lower BMIs. Saelens et al. (2003) reported more walkable neighborhoods correlated with lower
obesity prevalence. Sallis et al. (2009) reported that living in low-walkable, high income
neighborhoods was associated with a 53% increased risk of being overweight or obese, and low-
walkable, low income neighborhoods were associated with a 20% increased risk of being
overweight or obese.

Walkable neighborhoods have been correlated with less time spent in a vehicle (L. Frank
et al., 2006). Studies have shown that more time spent in a vehicle is correlated with fewer
minutes of physical activity and increased risks of obesity (L. D. Frank et al., 2004; Lopez-Zetina,
Lee, & Friis, 2006). Thus, it is imperative that public health interventions which focus on
removing barriers to walking be implemented in order to foster sustainable, healthy communities.

Increased walkability is also associated with better psychosocial health. Leyden (2003) and Wood et al. (2008) concluded through surveying that individuals residing in more walkable neighborhoods had higher social capital compared to those in less walkable neighborhoods (Leyden, 2003; Wood et al., 2008). Lund (2002) found that walkable neighborhoods in Portland, OR were associated with a greater sense of community. More walkable neighborhoods have been associated with greater neighbor-interaction, and those who walked more were more likely to interact and form relationships with their neighbors (Lund, 2003). Leslie and Cerin (2008) found that increased walkability is associated with increased quality of life (Leslie & Cerin, 2008). It is evident that walkability can be linked to many aspects of health.

In addition to having a positive impact on health, walkability has environmental benefits. Walking is a more sustainable form of transportation as it is not associated with the emission of harmful greenhouse gases. Transportation is the second leading cause of greenhouse gas emissions (Environmental Protection Agency, 2012). Many non-work trips are within a reasonable walking distance; 14 percent are within a half-mile distance from the home, and 27 percent are within one mile (Sallis et al., 2004). Decreasing the amount of vehicle trips would ultimately lead to increased air quality. Creating a walkable built environment and promoting active transport would likely result in a large positive environmental impact.

**Walkability and disparities.**

Research has shown that health disparities exist in which the burden of disease is greater among minority populations and low-income communities with regard to health promoting built environments. Individuals of lower SES are thought to be more influenced by
the built environment because they are more constrained to it due to lack of transportation and
mobility (Papas et al., 2007). Thus, low income individuals would be more negatively impacted
by an obesogenic environment than would someone of higher SES in the same environment.

Studies examining disparities show potential for walkability as a means to increase
physical activity levels for vulnerable populations. McDonald (2008) found that minority and
low SES children were more likely to participate in active transport due to a lack of resources.
Zhu (2008) examined walkability around an elementary school and found that the percent of
Hispanic students was predictive of more walkable neighborhoods, but also of higher dangers
from crime and traffic. Greenberg & Renne (2005) surveyed New Jersey residents and found
that black respondents were more likely than white respondents to report that they would walk
more if their neighborhoods were more walkable. Cutts et al. (2009) found that walkable
neighborhoods were more common in low-income, minority Census blocks, however, crime
rates were higher. Low income, minority populations often lack access to health promoting
built environments. Safe, walkable environments create an opportunity to increase physical
activity through walking and active transport; however, other social factors may need to be
simultaneously addressed.

Measuring walkability.

Many studies have examined built environment characteristics and their impact on
walking. In a review of the literature Saelens & Handy (2008) found five studies on accessibility
based on distance, three on mixed land use, and three on density. Six studies found that
neighborhood aesthetics were associated with more walking; four that found sidewalks and
street connectivity correlated with more walking, four that found that safety was a correlate of
walking, and three studies found that a general composite measure of neighborhood
‘walkability’ was correlated with more walking (B. Saelens & Handy, 2008). With so many
environmental correlates of walking, it is difficult to encompass all factors which may influence walkability.

Walkability has been measured in a number of different ways. Some studies have focused on perceived walkability and used survey methodology to determine influencing factors, many of which measure very similar constructs. Surveys include the Twin Cities Walking Survey (A. Forsyth, Schmitz, & Oakes, 2003), St. Louis Environment and Physical Activity Questionnaire (Brownson, Chang, & Eyler, ), International Physical Activity Questionnaire (Craig et al., 2003), and Environmental Supports for Physical Activity Questionnaire (Kirtland et al., 2003). One questionnaire seen frequently is the 98 question Neighborhood Environment Walkability Survey (NEWS) or the abbreviated version, NEWS-A (B. Saelens & Sallis, 2002). This instrument (like most others) measures perceived residential density, land use mix, street connectivity, infrastructure for walking/cycling, neighborhood aesthetics, and traffic/crime safety. In search of a short, “quick and dirty” assessment tool, the Leyden Walkability Instrument (LWI) was developed (Bias, Leyden, Abildso, Reger-Nash, & Bauman, 2010). This instrument contains 15 destinations and respondents are asked if they could walk to each “without too much trouble” (Bias et al., 2010). Though, to measure specific built environment characteristics, this instrument must be used in combination with another tool.

Walkability can be measured objectively as well. Cervero & Kockelman (1997) examined the influence of what they called the 3 Ds - density, diversity, and design, on walking behaviors. In 2010 the San Diego Association of Governments (SANDAG) developed a trip calculator that encompasses 7 Ds (density, diversity, design, destination accessibility, distance to transit, demographics, development scale) (San Diego Association of Governments (SANDAG), 2010). Zhu & Lee (2008) measured walkability around elementary schools by residential density, land use mix, street connectivity, and street level data (such as availability of sidewalks and posted
speed limit signs). Objective measures of walkability often utilize geographic information systems (GIS) either alone or in combination with field measures to examine the built environment. Of the various measures, there are often three core constructs that are included: connectivity, land use mix, and density. More recently, Frank et al. (2010) published a walkability index derived from Census block group level and parcel data in GIS which measures four components: net residential density, intersection density, land use mix, and retail floor area ratio. The ratio measure of retail floor area indicates the proximity of retail development to the roadway; with a low ratio signifying large parking lots and non-pedestrian friendly environments (Leslie et al., 2007). This construct serves as a means to measure the pedestrian friendliness of the environment. This walkability index has been utilized in numerous studies and potentially serves as the current standard walkability measure (Frank et al., 2006; Norman et al., 2006; Owen et al., 2007; Leslie et al., 2007; Kligerman et al., 2007; Gebel, Bauman, & Owen, 2009).

There has been evidence to show that perceived walkability is highly correlated with objective measures of walkability, exemplifying that residents are able to accurately gauge if their neighborhood is walkable. Several studies in Australia (Leslie et al., 2005) and the U.S. (Adams et al., 2009; B. Saelens et al., 2003) compare residents’ perceptions of walkability to an objective measure of walkability based on GIS data. All found that residents’ perceptions of walkability were related to the objective measures.

It is consistently evident in the literature that the built environment influences physical activity. However, the design of the built environment has changed considerably over the last century. Cities used to be built to accommodate walking, as it was the main form of transportation. However, the popularity of the automobile resulted in a dramatic transformation in the way cities were designed. With the option now to live outside of walking distance but still commute to work, the cities began to sprawl out beyond their original
boundaries (Frumkin et al., 2004, p. 26). The phenomenon of sprawl is one that has been costly in the form of economics, environmental health, and human health (Frumkin et al., 2004, p. 2).

**Urban Sprawl.**

Urban sprawl has become a common term used in the fields of both public health and urban planning. Gillham (2002) defines sprawl as, “a form of urbanization distinguished by leapfrog patterns of development, commercial strips, low density, separated land uses, automobile dominance, and a minimum of public open space” and adds a secondary definition of, “the typical form of most types of late-twentieth-century suburban development.” Sprawl has become synonymous with ‘suburbia’ and has expanded rapidly over the last century (Gillham, 2002).

Transportation changes have played a large role in the development of sprawl. The transportation revolution of the 19th century introduced steam ferries, horsecars, commuter railroads, elevated railroads, and the cable cars (Frumkin, Frank, & Jackson, 2004b, p. 27). These technological advances permitted individuals to live further from work, making suburban homes an appealing option to many (Frumkin, Frank, & Jackson, 2004b, p. 28). In the years following the civil war, a number of factors contributed to the expansion of suburbia. An agricultural depression took place, making land plentiful and cheap. A new, less expensive, construction method was introduced in which a small number of standard parts could be constructed with little craftsmanship to create a durable home. And lastly, tax policies were favorable towards home ownership. Utilities such as sewers and roads were built at the public’s expense through taxing the entire city and interest which was paid on mortgage loans could be deducted from taxes. Post war developers began to market suburbia as private and romantic places which signified that you had ‘made it’ and arrived at a fixed place in society (Frumkin, Frank, & Jackson,
This availability of affordable housing and prestige of home ownership drew many from the city into the suburbs (Frumkin, Frank, & Jackson, 2004b, p. 33).

The automobile age further transformed the suburbs. With push from various interest groups such as the tire, oil, automobile, and road building industries, roads became a publicly funded entity (Frumkin, Frank, & Jackson, 2004b, p. 35). As private automobile ownership grew, individuals could now reside further outward, no longer dependent on rail or ferry lines. As this outward sprawl continued, less dense patterns of land use emerged (Frumkin, Frank, & Jackson, 2004b, p. 36). This new pattern of land use which combines cities and suburbs is now referred to as a ‘metropolitan area’ (Gillham, 2002).

With the growth of metropolitan areas, employment started to become decentralized. In 1948, the numbers of jobs in central cities were twice that of the suburbs. Currently there is more employment located in the suburbs than there is in the central city (U.S. Census, 2010). This decentralization is problematic if public transit is not as readily accessible to city suburbs, especially for low income and minority populations who are the predominant users of public transit. A report by the Brookings Institute found that of the 100 largest metropolitan areas, a resident can reach only 30% of jobs via mass transit within a 90 minute commute (Tomer, Kneebone, Puentes, & Berube, 2011).

This low density land use pattern became complicated further due to zoning laws. These laws are enacted by local governments to separate one set of land use from another, ie: houses, parks, retail, and offices are kept separate; this is referred to as single use zoning (Frumkin, 2009). This sprawling, single-use land pattern has resulted in increased trip distances, making active transport inconvenient. Vehicular travel is now a virtual necessity to complete daily errands (Frumkin, 2009). Sprawl is also associated with more vehicle miles traveled (L. Frank et al., 2006; Frumkin, 2009; Lopez-Zetina et al., 2006). These design choices have had negative
implications on urban health including issues of air quality, pedestrian safety and injury, increased chronic medical conditions and decreased health related quality of life, increased sedentary lifestyles, and decreased levels of social capital (Frumkin, 2009).

Automobiles are the leading source of air pollution and contribute significantly to the production of greenhouse gasses (L. Frank et al., 2006; Frumkin, 2009). These pollutants contribute to an increase in “incidence and severity of respiratory symptoms, worse lung function, more emergency room visits and hospitalizations, more medication use, and more absenteeism from school and work” (Frumkin, 2009). Urban sprawl is correlated with an increased amount of vehicle miles traveled, which is associated with increased air pollution. Thus, sprawl has contributed to the resultant negative health implications of increased morbidity and mortality (L. Frank et al., 2006; Frumkin, 2009).

Sprawl has been shown to correlate with decreased pedestrian safety. Ewing, Schieber, & Zegeer (2003) found that urban sprawl was directly linked to traffic fatalities, with the most sprawling counties having four times the average of traffic fatality rates (Ewing, Schieber, & Zegeer, 2003). Hanzlick et al. (1999) reported that the most dangerous road types were those with high speeds and multiple lanes which lack sidewalks, have long distances between crosswalks, and are lined with commercial establishments; all features which are typical of sprawl (Frumkin, 2002; Hanzlick et al., 1999). In their annual report Dangerous By Design 2011, Transportation for America reported that pedestrian fatalities dropped only by 14% in the last decade, compared to a 27% decline for individuals traveling inside of a vehicle. Pedestrian fatalities have actually increased in 15 of the largest metropolitan areas (Ernst, 2011).

Built environment features typical of sprawl have been correlated with decreased measures of physical activity (Ewing, Schmid, Killingsworth, Zlot, & Raudenbush, 2008; Frumkin, Frank, & Jackson, 2004a; Sallis et al., 2009). As previously mentioned, street networks are an
important factor in physical activity since they influence mode choice. Street design associated with sprawl is one that favors the automobile, high speed throughway streets with a low intersection density which makes active transport difficult and inconvenient. Low density land use patterns typical of sprawl have been consistently correlated with decreased rates of physical activity (L. Frank et al., 2006; L. D. Frank et al., 2005; Frumkin, Frank, & Jackson, 2004b; B. Saelens et al., 2003; B. E. Saelens et al., 2003). Sprawling neighborhoods have a low residential density, which is also correlated with decreased physical activity (L. D. Frank et al., 2005; Frumkin, Frank, & Jackson, 2004b). This is a concern for public health due to the association between physical inactivity and increased morbidity and mortality. In order to reduce the current sedentary lifestyle, it is essential to create an environment which promotes physical activity rather than hindering it.

Urban sprawl has been shown to predict chronic medical conditions and poorer health related quality of life (R. Sturm & Cohen, 2004). Sturm & Cohen (2004) used a linear regression model to examine the relationship between self-reported health data and the sprawl index. “An increase in sprawl from one standard deviation less to one standard deviation more than average implies 96 more chronic medical problems per 1000 residents (R. Sturm & Cohen, 2004).” This is the equivalent of aging the population by 4 years (R. Sturm & Cohen, 2004).

In addition to physical health, urban sprawl and suburbia have had negative effects on social capital. Social capital can be defined as “features of social life – networks, norms, and trust – that enable participants to act together more effectively to pursue shared objectives” (Putnam, 1995, pp. 664). Having social support and being socially and civically engaged are indicative of fewer morbidities and longer life (Frumkin, Frank, & Jackson, 2004b). Kawachi et al. (1997) examined social capital levels and mortality rates of 39 states and found that as social capital decreased, age-adjusted mortality increased. Hutchinson et al. (2009) found that all-
cause black mortality was lowest in neighborhoods which had higher social capital. Nieminen et al. (2010) reported that social capital was associated with good self-rated health and psychological wellbeing (Nieminen et al., 2010). Thus, social capital has a positive impact on health. Frank et al. points out a number of ways that sprawl undermines social capital. First, sprawl restricts the time and energy that people have available for civic engagement (Frumkin, Frank, & Jackson, 2004b). Putnam notes that each 10 minutes of commute time is associated with a 10% decrease in civic involvement (Frumkin, Frank, & Jackson, 2004b; Putnam, 2000). “Second, sprawl could undermine social capital by reducing opportunities for spontaneous, informal social interaction” (Frumkin, Frank, & Jackson, 2004b). Third, those that live in suburban areas often value privacy over interaction, and by “sanctifying the private realm, sprawl undermines people’s support for public initiatives” (Frumkin, Frank, & Jackson, 2004b). Fourth, as people age and family structure changes, older individuals may wish to downsize the size of their home. However, because suburb homes are homogeneous there are often little to no options within the same neighborhood and individuals are forced to relocate (Frumkin, Frank, & Jackson, 2004b). Research supports this view. Rogers & Sukolratametee (2009) found that residents of traditionally designed neighborhoods felt an enhanced sense of community when compared to suburban neighborhoods and Nasar & Julian found that residents of a mixed-use community felt more sense of community than did those of a single use community (Nasar & Julian, 1995; Rogers & Sukolratametee, 2009). Sprawl has played an integral part in the decline of social capital.

Sprawl also increases the amount of driving which is recognized as an important source of stress and thus a negative influence on mental health. Studies from Germany, London, and the United States found that driving was associated with increases in stress responses including increased heart rate, ectopic heartbeats, ischemia, angina, and left ventricular failure (Frumkin,
Frank, & Jackson, 2004b). A Philadelphia study found that after two hours of city driving, urinary stress hormones were increased (Frumkin, Frank, & Jackson, 2004b). A study in Miami found that University students had increased blood pressure, heart rate, and lower frustration tolerance after 45 minutes of city driving (White & Rotton, 1998), and a Toronto study found that while in the process of city driving, drivers were considerably stressed and used terms such as “frustrated,” “distressed,” “uneasy,” and “losing my temper” (Frumkin, Frank, & Jackson, 2004b; Hennessy & Wiesenthal, 1997). It is clear that driving is a stressor, thus commuting daily can be a chronic and persistent stressor with associated health consequences (Frumkin, Frank, & Jackson, 2004b). This is supported by a number of research studies finding that longer commute times were predictive of high blood pressure, increased neck and back pain, more lost work days and late arrivals, a higher turnover rate, “tense” and “nervous” feelings, more sick days and self-reported cold and flu, and more days in the hospital (Frumkin, Frank, & Jackson, 2004b).

In summary, political, social, technological, and environmental changes have resulted in a built environment that is dramatically different from that of 100 years ago. Cities have become large, sprawling, metropolitan areas which require vehicular transport. These changes have not come without consequences to human and environmental health. The Las Vegas Metropolitan area (LVMA) is one such sprawling city worth studying, as it possesses unique urban design characteristics significant to physical activity and walkability. It contains many single entry or gated communities. Street design has led to the creation of numerous high speed arterial streets with large distances between cross walks. The lack of an older ‘core’ has resulted in decentralization of jobs and made efficient public transit options difficult to attain. And, the desert climate makes tree shade a necessity in the summer sun.
Welcome to fabulous, sprawling Las Vegas.

Much of the American west is sprawling. Batty, Besussi, & Chin (2003) note that, “unplanned, uncoordinated, decentralized development is characteristic of many newer cities, particularly those in the American south and west.”

Nevada’s population boom occurred simultaneously with the growth of gaming in the 1950s. According to the U.S. Census Bureau, Nevada has been the fastest growing state since 1960. Las Vegas is the largest city in Nevada with a total population of nearly 2 million and a land area of 7,892 square miles (Census 2010, 2011). The LVMA is a newer, urban, sprawling, desert metropolis. As a result, LVMA has many unique urban design characteristics which impact the public health and safety of its residents.

LVMA’s rapid population growth coincided with the automobile age; consequently, the Las Vegas metropolitan area is auto-centric, caters to the automobile, and lacks an older ‘core’. The auto-centric design has resulted in a street network planned for the fast transport of automobiles from one part of the metropolitan area to the next. The LVMA consists of a “traditional street grid pattern with major surface arterial streets at every mile, and rights-of-way adequate to provide for six or eight lanes of traffic that generally travels at or above the posted speed limit of 45 miles per hour” (Nambisan & Dangeti, 2008). The numerous high speed arterial streets do not make for a pedestrian friendly environment. Dumbaugh & Ray (2009) found that each additional mile of arterial road within a neighborhood was associated with a 15% increase in total crash incidence and a 17% increase in injury crash incidence. Using pedestrian fatality data and the census data on walking, the Dangerous By Design 2011 report identifies the 52 most dangerous metropolitan areas for walking; this report ranked Las Vegas, NV the 6th most dangerous city in the U.S. (Ernst, 2011).
The auto-centric design of LVMA has also resulted in long distances between crosswalks. Crosswalks are typically located at the corners of busy arterial intersections, with very few options for crossing in between. This often times results in crosswalks being located further apart than the standard acceptable walking distance of one quarter mile. This design characteristic has negative effects on active transport, as well as pedestrian safety. First, the large distance between crosswalks makes non-vehicular travel inconvenient. Second, pedestrian safety is compromised if crossing occurs outside of the crosswalk, as driver-yielding behaviors are increased in the presence of crosswalks (Van Houten & Malenfant, 1992). The majority of pedestrian crashes in LVMA (of which the police have deemed the pedestrian at fault) are a result of darting into the street outside of a crosswalk (Pharr, Coughenour, & Paz, in press). Long distances between crosswalks play a significant role in pedestrian safety in LVMA.

The auto-centric design of LVMA and the resultant lack of an older ‘core’ have played a significant role in the development of a public transit system. Fulton (2001) notes that cities built in such a manner make it difficult to provide efficient public transit options (Fulton, Pendall, Nguyen, & Harrison, 2001). LVMA does not offer any city-wide rail transit options; however a monorail does service part of the resort corridor, ‘the strip’. The only city-wide transit option is a bus system operated by the Regional Transportation Commission of Southern Nevada (RTC). The transit fleet consists of 36 routes which service most of the LVMA (Regional Transportation Commission of Southern Nevada, 2012). A Brookings report (2011) found that 86% of the working population in Las Vegas lives within 0.75 miles of a transit stop (Tomer et al., 2011). However, it is a widely accepted that walking distance influences transit use (Biba, Curtin, & Manca, 2010), and the maximum distance that most users are willing to walk to reach transit is 0.25 miles (Biba et al., 2010). It has been found that transit use declines at a walk distance of 0.06 miles and virtually disappears after 0.36 miles (Zhao, Chow, Li, Ubaka, & Gan, 2003).
Loutzenheiser (1997) found that for every 0.31 miles from a transit stop, the probability that an individual will walk to transit decreases by 50% (Biba et al., 2010; Loutzenheiser, 1997). Travel time, convenience, and reliability are all factors that are considered when choosing travel mode (Zhang, 2004). Thus, convenient access to transit is essential if urban design is to promote transit use.

Common interest housing developments (CIDs) or gated communities gained significant popularity in LVMA beginning in the 1990s. They consist of a private government or homeowner associations which are responsible for matters that would otherwise be the responsibility of local government, for example: trash collection, leaf removal, repair of street lights, and park maintenance (McKenzie, 2005). They often consist of gates and high privacy walls surrounding individual lots (McKenzie, 2005). These neighborhoods are typically homogeneous, both demographically and socially. Some scholars have compared gated communities to social segregation (Atkinson & Blandy, 2006; Vesselinov, 2008). It is argued that such communities reflect the hierarchy of wealth and further segregate the disadvantaged (Gooblar, 2002). Gated communities are the dominant form of new residential development in LVMA (McKenzie, 2005). Furthermore, there is a movement to add walls and gates to older developments in LVMA to make them more like the newer communities (McKenzie, 2005).

The phenomenon of gated communities in LVMA is significant in terms of physical activity and pedestrian safety. First, because gated communities often contain only one access point both in and out of the development, it significantly increases trip distance. Not only for residents inside the gate, but also for residents in surrounding communities, as they are forced to walk completely around the walls (Burke & Sebaly, 2001). Thus, participating in active transport has become much less convenient. The streets within and directly outside of the gated community are designed in a street hierarchy, which consists of cul-de-sacs, or non-
connecting streets which flow to sub-collector streets, to higher volume collector streets, then to major arterials (Burden, 1999). The underlying theory was that such suburbs would create a social environment which was safe for children to play, yet it increased traffic flow via the arterials (Ben-Joseph, 1997). The result is that hierarchical design has created a safe pedestrian environment within cul-de-sacs and non-connecting streets, but has made non-motorized travel outside them dangerous and nearly impossible.

Gated communities have also been associated with decreased social capital. Burke & Sebaly (2001) found that gated communities have significantly less ‘street vitality’, defined as the quality whereby a street portrays life through the display of human activity (Burke & Sebaly, 2001). DeFilippis (2001) notes that gated community residents in Orange County, CA had significantly less bridging social capital than non-gated residents (DeFilippis, 2001).

LVMA is unique from non-south western cities in that it is a desert city with an arid climate and thus experiences extreme weather in the summer months. The average high temperature is over 90°F Fahrenheit four months out of the year with the majority of days being clear and sunny (The Weather Channel, 2012). The arid climate is significant in terms of walkability, as extreme weather has been identified as a barrier to physical activity (Tucker & Gilliland, 2007). An urban design characteristic employed to minimize the impact of this extreme heat is the use of shade trees. Such trees are important in mode of transportation choices, as they make walking and active transport more pleasant and desirable.

The phenomenon of sprawl in the United States is becoming undesirable. It is being recognized as excessive growth which is harmful to health and unsustainable. New ways of designing and retrofitting neighborhoods to combat sprawl and counteract the related consequences are being discussed. One such discussion is taking place in LVMA.
In 2006 the municipal agencies of Southern Nevada completed a project using a modeling tool to examine the effects of land use and transportation on air quality, time in traffic, and population of the region. The model tested scenarios involving changes to densification, land use, transit, and combinations of the three versus the effects of maintaining the status quo. They found that maintaining the status quo “will mean significant increases in traffic congestion and air pollution” (Southern Nevada Regional Planning Coalition, 2006). It was reported that in order to make improvements, combinations of densification, mixed use and transportations are required. More specifically, an increase in housing density, traffic flow, and use of alternative transportation and a decrease in distance per trip and number of vehicle trips are required. Such changes will keep time spent in traffic from increasing, keep air pollution within or below EPA standards, and avoid a decrease in population growth (Southern Nevada Regional Planning Coalition, 2006).

Correspondingly, changes in housing demand are already taking place. Doherty and Leinberger (2010) illustrate that the millennial generation (those born between 1977 and 1994) no longer prefer suburbia, but rather a denser, urban design which allows for the use of both active and public transportation. Additionally, the baby boomers (those born between 1946 and 1964) are finding their suburban homes too large after their children are gone and are also seeking to relocate to a denser design which provides them with transit options (The Segmentation Company (TSC), 2006). This is evident in the real estate market, as home values in urban walkable cities “have experienced less than half of the average decline in price from the housing peak (The Segmentation Company (TSC), 2006).” Studies have also shown that residents are willing to pay a premium for walkable neighborhoods. One study examined the connection between home values and walkability in 15 metropolitan areas and found that, when compared to houses with average levels of walkability, houses with above average walkability were valued
between $4,000 and $34,000 more (Cortright, 2009). Song and Garrit-Jan (2003) examined new urbanism characteristics and found that home buyers pay a premium for interconnected streets and walkability to commercial uses. Additionally, homes located near light rail stations sold at higher property values (Song & Gerrit-Jan, 2003).

It is also important for the economic vitality of LVMA to understand and embrace these changing demands. One survey found that 64% of college-educated millennials report that they will make a choice on where they prefer to live first, then look for a job in that area second (The Segmentation Company (TSC), 2006). Additionally, 71% report that they would consider living a downtown area and 80% report that they would consider living in a neighborhood near the downtown area (The Segmentation Company (TSC), 2006). This population also reports that weather plays a big role in deciding where to live (The Segmentation Company (TSC), 2006). Given the already desirable climate, LMVA has the potential to become a sought-after destination for this population of young talent if we are able to offer a sustainable, walkable, urban environment.

For LVMA to become a sustainable, healthy, and marketable metropolitan area, it is imperative that we invest in alternate modes of transportation. Increasing walkability will ultimately result in more trips through active transport and have beneficial outcomes on congestion and air pollution. In order to properly focus prevention and intervention efforts, as well as allocate funding and resources, it is necessary to understand all of the factors that influence walkability in the LVMA.
Chapter 3

Methods

The primary aim of this study was to determine what built environment characteristics are associated with walking and physical activity in LVMA. The intention was to develop a more sensitive measure of walkability for moderate income neighborhoods in LVMA by measuring the perceived influence of design characteristics unique to LVMA in addition to features captured in the four-component standard walkability index. Five unique design characteristics were hypothesized to influence walkability in LVMA. They include lack of tree shade, the distance between crosswalks, presence of high speed streets, presence of single entry communities, and access to transit. To investigate this, the walkability index developed by Frank et al. (2010) was used to select two low walkability and two high walkability neighborhoods. Residents were then surveyed on their weekly minutes of physical activity and how much the four components in the standard walkability index and the five unique design characteristics influenced their decisions to walk. Logistic regression models were applied to determine if perceived measures of the built environment were associated with attaining the recommended levels of physical activity.

Research question: What neighborhood design characteristics are associated with walking and physical activity in LVMA?

H1: Residents will perceive neighborhood design characteristics as a barrier to walking.

P1: Residents will report large parking lots as a barrier to walking.

P2: Residents will report poor land use mix as a barrier to walking.

P3: Residents will report poor street connectivity as a barrier to walking.

P4: Residents will report low residential density as a barrier to walking.

P5: Residents will report lack of shade as a barrier to walking.

P6: Residents will report the presence of single entry communities as a barrier to walking.
P7: Residents will report the presence of high speed streets as a barrier to walking.

P8: Residents will report long distances between crosswalks as a barrier to walking.

P9: Residents will report that better access to transit would enable them to walk more.

H2: Single entry communities result in an overestimate of walkability.

P1: Intersection density will decrease significantly after adjusting for the presence of single entry communities.

H3: Perceptions of neighborhood design characteristics as barriers to walking will be associated with fewer minutes of physical activity.

P1: Residents who report large parking lots as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity.

P2: Residents who report poor land use mix as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity

P3: Residents who report poor street connectivity as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity

P4: Residents who report low residential density as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity

P5: Residents who report lack of shade as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity.

P6: Residents who report single entry communities as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity.

P7: Residents who report high speed streets as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity.

P8: Residents who report long distances between crosswalks as a barrier to walking will attain fewer minutes of active transport, total walking, and physical activity.
P9: Residents who report that better access to transit would result in increased walking will attain fewer minutes of active transport, total walking, and physical activity.

Choosing Neighborhoods.

Moderate income neighborhoods were chosen for this study, as the intention was to determine what built environment characteristics were associated with walking. Studies show that low income individuals are more likely to be ‘captive walkers,’ walking not out of choice, but out of necessity because they do not have access to a private vehicle. Such individuals are more likely to walk regardless of the design of the built environment (Lovasi, Neckerman, Quinn, Weiss, & Rundle, 2009; Murakami & Young, 1997).

Census block group level data was chosen as the geographic scale because of the availability of income data at this level; one census block group was chosen to represent a ‘neighborhood.’ Income data from the American Community Survey (ACS) 2010-5 year estimates were downloaded using the U.S. Census DataFerrett (U.S. Census Bureau, 2010). ACS data was joined in ArcGIS with the Census2010 block group shape file downloaded from the U.S. Census Bureau website. Eligible Census block groups were limited to those with a median household income between $38,521 and $101,582. These income brackets were chosen because they represent the 3rd and 4th Census Bureau income quintiles for 2011 (U.S. Census Bureau, 2011b).

Seven neighborhoods were then chosen which differed geographically across LVMA. In order to make surveying possible, neighborhoods were limited to those with 450 to 700 households. The standard walkability index was then calculated for each neighborhood based on the methods developed by Frank et al. (2010).
Measuring the Standard Walkability Index.

The standard walkability index consists of the utilization of GIS software to measure four components of the built environment: net residential density, retail floor area ratio, intersection density, and land use mix. These data were retrieved from parcel-based land use data and street center line data (supplied by Clark County Assessor’s Office). Parcel data was spatially joined to the Census2010 data to calculate each component. See Table 1 for a description of each component. The four calculated values are then normalized using a Z-score and summed. The Z-score value of intersection density is weighted by a factor of 2, as street connectivity (a measure of a more direct path) has a strong influence on walking behaviors. The walkability index is a sum of the Z-scores of the four built environment components:

\[
\text{Walkability} = [(2 \times Z\text{-intersection density}) + (Z\text{-net residential density}) + (Z\text{-retail floor area ratio}) + (Z\text{-land use mix})]
\]

The walkability index scores ranged from -5.64 to 5.36. Neighborhoods were arranged in ascending order, least to most walkable, based on their walkability index scores. Residents of the two most walkable neighborhoods, those with the highest index scores, and two least walkable neighborhoods, those with the lowest index scores, were then targeted for surveying. See Figure 2 for a map of the seven neighborhoods in which the index was calculated, and the four neighborhoods which were targeted for surveying. Of the two least walkable neighborhoods, one was located in the south end of LVMA just north of St. Rose Parkway (Census 28422); the other was in the northwest part of LVMA near I95 and Durango Drive (Census 32305). Of the two most walkable neighborhoods, one was located in the southeast part of LVMA just east of Green Valley Parkway (Census 53331) and the other was in the east end of LVMA on the north side of Sahara Avenue (Census 49102).
<table>
<thead>
<tr>
<th>Component</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Residential Density</td>
<td>Number of residential units divided by land area in acres devoted to residential use.</td>
</tr>
<tr>
<td>Intersection Density</td>
<td>Number of true intersections (3 or more segments) divided by the land area of the block group in acres. A higher ratio indicates greater connectivity.</td>
</tr>
<tr>
<td>Land use mix</td>
<td>Diversity of land use types in a block group. Land use types include retail, residential, entertainment (parks, recreation facilities, theatres, restaurants), office, and institutional (schools, religious institutions, libraries/museums, community organizations, government facilities). Values were normalized between 0 and 1, with 0 being single use and 1 indicating a completely even distribution of floor area.</td>
</tr>
<tr>
<td>Retail Floor Area Ratio</td>
<td>Retail building area footprint divided by retail land area footprint. The higher the ratio is, the more indicative it is of pedestrian friendliness.</td>
</tr>
</tbody>
</table>
Figure 2. Map of LVMA, neighborhoods in which the index score was calculated, and four neighborhoods which were targeted for surveying.
Survey.

A survey was created as a tool to measure the association between perceptions of neighborhood walkability and weekly minutes of active transport, weekly minutes of total walking, and weekly minutes of total physical activity. The survey inquired about sociodemographic variables (age, race, gender, education), length of residence in the neighborhood, car ownership, residence in a gated community, and whether the respondent had an impairment or health problem that limited their ability to walk. Respondents who answered yes to having an impairment that limited their ability to walk were removed from analysis.

To determine how respondents perceived their neighborhood design, questions were created which asked about the four standard index characteristics and five unique design characteristics as a barrier to walking for active transport and a barrier to walking for pleasure. Questions were asked using a 6-point Likert scale ranging from strongly disagree to strongly agree. To determine if perceptions of neighborhood design were associated with minutes of physical activity, a modified version of the International Physical Activity Questionnaire (IPAQ) was used to measure weekly minutes of active transport, leisure walking, other vigorous and moderate physical activity, and time spent in a vehicle. This questionnaire was developed for adults aged 18 to 65 to measure four domains: transportation, work, leisure, and household and gardening. Questions regarding work and household and gardening were removed. The IPAQ has been previously validated (Hagströmer, Oja, & Sjöström, 2006). The paper survey was distributed in English with the option for a Spanish version by visiting a website for the online version of the survey. See Appendix A for the complete survey.
Participants.

The survey was distributed to each residence within the four neighborhoods by hanging a printed version on each door. A cover letter asked that at least 1 resident per household between the ages of 18 and 64 years participate in the survey by completing the printed version and returning it in a supplied business reply envelope, or by visiting a website to complete an electronic version of the survey (hosted by QUALTRICS). Participants were offered compensation for their time through entry into a drawing to win prizes and gift cards. The cover letter was printed in both English and Spanish (see appendix A for cover letter). A cardboard door hanger was distributed as a reminder approximately 2 weeks after the initial survey to each residence asking them to complete the electronic version of the survey (see appendix B for door hanger).

Adjusting for Single Entry Communities.

Single entry communities are not accounted for in the walkability index, yet this design characteristic has a direct influence on the most important feature of the index, intersection density (intersection density is weighted by 2 in the index). The number of true intersections (3 or more legs) is determined through ArcGIS, and this includes the intersections within single entry communities. However, these intersections are not true intersections as they don’t lead to anywhere except within the walled off community. Thus, they appear as contributing to intersection density or ‘as the crow flies’ route choices, when in actuality they do not.

To determine if the number of intersections were significantly different before and after accounting single entry communities a pilot study was conducted. The number of true intersections was calculated for 20 geographically different LVMA neighborhoods (Census block groups). The same neighborhoods were then assessed for the presence of single entry communities using ArcGIS imagery and Google maps. Intersections inside single entry
communities were then removed. A paired t test was used to assess the mean difference of intersection density before and after adjustment.

**Statistical Approach.**

Percent of residents who reported neighborhood design characteristics as a barrier to walking were examined. Correlations were used to examine the association between perceived neighborhood design characteristics and minutes of active transport, total walking, and total physical activity. Regression models were used to predict weekly minutes of active transport, total walking, and physical activity. Log transformations and Box-Cox transformations were applied to measures of physical activity in an attempt to normalize the data. T-tests were used to analyze the mean number of intersections before and after adjusting for single entry communities. Data was analyzed in SPSS version 19.
Chapter 4

Results

Neighborhood Selection.

The four-component standard walkability index was calculated for all seven geographically different neighborhoods. Table 2 shows the values for each component of the index. The two least walkable neighborhoods (Census 32305 and 28422) and the two most walkable neighborhoods (Census 53331 and 49102) were targeted for surveying.

Table 2

Four-component walkability index scores for seven LVMA census block groups (neighborhoods).

<table>
<thead>
<tr>
<th>Census</th>
<th>Residential Density</th>
<th>Intersection Density</th>
<th>Retail Floor Area Ratio (RFA)</th>
<th>Entropy Score (land use mix)</th>
<th>Walkability score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw Score</td>
<td>Z score</td>
<td>Raw Score</td>
<td>Z score</td>
<td>Raw Score</td>
</tr>
<tr>
<td>32305</td>
<td>9.33</td>
<td>-0.1</td>
<td>0.13</td>
<td>-3.02</td>
<td>0</td>
</tr>
<tr>
<td>28422</td>
<td>7.79</td>
<td>-1.05</td>
<td>0.26</td>
<td>0.55</td>
<td>0</td>
</tr>
<tr>
<td>17112</td>
<td>9.91</td>
<td>0.25</td>
<td>0.20</td>
<td>-1.10</td>
<td>0.311</td>
</tr>
<tr>
<td>32472</td>
<td>7.38</td>
<td>-1.3</td>
<td>0.29</td>
<td>1.37</td>
<td>0.43</td>
</tr>
<tr>
<td>16091</td>
<td>9.45</td>
<td>-0.03</td>
<td>0.22</td>
<td>-0.55</td>
<td>0.28</td>
</tr>
<tr>
<td>53331</td>
<td>10.38</td>
<td>0.54</td>
<td>0.22</td>
<td>-0.55</td>
<td>0.27</td>
</tr>
<tr>
<td>49102</td>
<td>12.23</td>
<td>1.688</td>
<td>0.36</td>
<td>3.30</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Survey Responses.

There were a total of 2,227 residences within the four surveyed neighborhoods. A total of 147 surveys were completed and returned for a 6.5% response rate. The majority of surveys were returned by mail (72%) and about a quarter were completed online through QUALTRICS. A total of 3 surveys were removed from analysis due to reporting yes to having a disability that limited their ability to walk. Table 3 shows the demographic breakdown of survey responses by neighborhoods. The mean age of respondents was 41.5 years and the mean length of residence
in the neighborhood was 5.8 years. The majority of respondents reported that they owned a vehicle (92%), and slightly less than half lived in a single entry community (49%). Of note, survey respondents were more educated than the general Las Vegas population; with 54.2% of respondents having a four-year college or greater compared to 22.2% of LVMA residents (U.S. Census Bureau, 2011a).

Table 3

<table>
<thead>
<tr>
<th>Race</th>
<th>32305(NW) (n=35)</th>
<th>28422(S) (n=31)</th>
<th>53331(SE) (n=58)</th>
<th>49102(E) (n=20)</th>
<th>Total (n=144)</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>21</td>
<td>18</td>
<td>46</td>
<td>10</td>
<td>96</td>
</tr>
<tr>
<td>Non-white</td>
<td>14</td>
<td>13</td>
<td>12</td>
<td>10</td>
<td>51</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21</td>
<td>20</td>
<td>44</td>
<td>14</td>
<td>99</td>
</tr>
<tr>
<td>Male</td>
<td>13</td>
<td>11</td>
<td>14</td>
<td>6</td>
<td>44</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than college</td>
<td>18</td>
<td>17</td>
<td>16</td>
<td>15</td>
<td>66</td>
</tr>
<tr>
<td>4yr degree or greater</td>
<td>17</td>
<td>14</td>
<td>42</td>
<td>5</td>
<td>78</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29 years</td>
<td>6</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>25</td>
</tr>
<tr>
<td>30-39 years</td>
<td>9</td>
<td>11</td>
<td>9</td>
<td>5</td>
<td>34</td>
</tr>
<tr>
<td>40-49 years</td>
<td>15</td>
<td>7</td>
<td>18</td>
<td>7</td>
<td>47</td>
</tr>
<tr>
<td>50-59 years</td>
<td>5</td>
<td>2</td>
<td>18</td>
<td>3</td>
<td>28</td>
</tr>
<tr>
<td>60-64 years</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

NW=northwest, S=south, SE=southeast, E=east

When asked if urban design characteristics influenced walking behaviors, 49.3% agreed that lack of shade prevented them from walking for pleasure and 39.9% agreed that lack of shade prevented them from walking for active transport. Land use mix played an important role in walking behaviors with 39.2% agreeing that poor land use mix prevented them from walking for active transport and 33.3% agreeing that it prevented them from walking for pleasure. In
Census block group 28422 (S) the majority of respondents reported that poor land use mix prevented them from walking for active transport (81.3%), and walking for pleasure (78.1%). Respondents in Census block group 28422 (S) were 6.5 times more likely to report poor land use mix as a barrier to active transport and 11.2 times more likely to report it as a barrier to walking for pleasure than respondents in Census block group 53331 (SE). Street connectivity was also an important factor in walking behavior with 32.2% agreeing that poor connectivity prevented them from walking for active transport and 30.3% agreeing that it prevented walking for pleasure. Poor street connectivity was reported as preventing walking by a larger percentage of respondents in two of the neighborhoods (Census 28422 [S] and Census 49102 [E]). Large distances between crosswalks and the presence of high speed streets were reported by a large percentage of respondents in two of the neighborhoods (Census 28422 [S] and Census 49102 [E]). Respondents in Census block group 49102 (E) were more than 40 times more likely to report large distances between crosswalks as a barrier to walking for pleasure and 25.3 times more likely to report it as a barrier to active transport than respondents in Census block group 53331 (SE). When compared to Census block group 53331 (SE), respondents in Census block group 28422 (S) were 3.6 times more likely to report high speed streets as a barrier to walking for pleasure and 3.1 times more likely to report it as a barrier to active transport and 2.9 times more likely to report that improved access to transit would result in more walking. All responses to survey questions which asked about each design characteristic as a barrier to walking are listed in Table 4.
Table 4

Percent of respondents who agree that the design characteristic prevents walking behaviors

<table>
<thead>
<tr>
<th>Design Characteristic</th>
<th>SE</th>
<th>NW</th>
<th>E</th>
<th>S</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of shade prevents walking for pleasure</td>
<td>33.3</td>
<td>58.8</td>
<td>45.5</td>
<td>65.6</td>
<td>49.3</td>
</tr>
<tr>
<td>Lack of shade prevents walking for AT</td>
<td>25.0</td>
<td>44.1</td>
<td>50.0</td>
<td>53.1</td>
<td>39.9</td>
</tr>
<tr>
<td>Single entry communities prevents walking for pleasure</td>
<td>7.0</td>
<td>17.6</td>
<td>4.5</td>
<td>12.5</td>
<td>11.1</td>
</tr>
<tr>
<td>Single entry communities prevents walking for AT</td>
<td>8.9</td>
<td>23.5</td>
<td>9.1</td>
<td>9.4</td>
<td>12.6</td>
</tr>
<tr>
<td>Distance between crosswalks prevent walking for pleasure</td>
<td>0</td>
<td>8.8</td>
<td>42.9</td>
<td>38.7</td>
<td>17.5</td>
</tr>
<tr>
<td>Distance between crosswalks prevent walking for AT</td>
<td>1.8</td>
<td>8.8</td>
<td>45.5</td>
<td>40.6</td>
<td>18.9</td>
</tr>
<tr>
<td>High speed streets prevent walking for pleasure</td>
<td>12.3</td>
<td>17.6</td>
<td>27.3</td>
<td>43.8</td>
<td>19.4</td>
</tr>
<tr>
<td>High speed streets prevent walking for AT</td>
<td>14</td>
<td>26.5</td>
<td>22.7</td>
<td>43.8</td>
<td>25.0</td>
</tr>
<tr>
<td>Large parking lots prevent walking for pleasure</td>
<td>8.8</td>
<td>32.4</td>
<td>31.8</td>
<td>15.6</td>
<td>19.4</td>
</tr>
<tr>
<td>Large parking lots prevent walking for AT</td>
<td>8.8</td>
<td>33.3</td>
<td>31.8</td>
<td>18.8</td>
<td>21.0</td>
</tr>
<tr>
<td>Poor land use mix prevent walking for pleasure</td>
<td>7.0</td>
<td>29.4</td>
<td>36.4</td>
<td>78.1</td>
<td>33.3</td>
</tr>
<tr>
<td>Poor land use mix prevent walking for AT</td>
<td>12.5</td>
<td>38.2</td>
<td>40.9</td>
<td>81.3</td>
<td>39.2</td>
</tr>
<tr>
<td>Poor street connectivity prevents walking for pleasure</td>
<td>10.5</td>
<td>32.4</td>
<td>40.9</td>
<td>59.4</td>
<td>30.6</td>
</tr>
<tr>
<td>Poor street connectivity prevents walking for AT</td>
<td>14.3</td>
<td>29.4</td>
<td>40.9</td>
<td>62.5</td>
<td>32.2</td>
</tr>
<tr>
<td>Poor residential density prevents walking for pleasure</td>
<td>3.5</td>
<td>8.8</td>
<td>27.3</td>
<td>25.0</td>
<td>13.2</td>
</tr>
<tr>
<td>Poor residential density prevents walking for AT</td>
<td>1.8</td>
<td>5.9</td>
<td>22.7</td>
<td>28.1</td>
<td>11.9</td>
</tr>
<tr>
<td>Convenient access to transit result in greater amounts of walking</td>
<td>16.1</td>
<td>23.5</td>
<td>36.4</td>
<td>46.9</td>
<td>26.6</td>
</tr>
</tbody>
</table>

*AT = active transport

Figure 3 uses a bar graph to depict the percentages of respondents in each neighborhood who agree that the design characteristic is a barrier to walking. The Likert scale was collapsed into agree (somewhat agree, agree, and strongly agree) or disagree (somewhat disagree, disagree, strongly disagree).
Figure 3. Percent of respondents in each neighborhood who report neighborhood design characteristics as a barrier to walking.

Analysis.

The weekly number of minutes of active transport, weekly number of minutes of total walking (active transport + leisure walking), and the weekly number of minutes of physical activity are presented in Table 4.
activity (total walking + moderate exercise + vigorous exercise) were calculated. Table 5 shows the means of each neighborhood and total means from survey responses.

Table 5

Means of weekly minutes of active transport, total walking, and physical activity (n=144)

<table>
<thead>
<tr>
<th></th>
<th>32305 (NW)</th>
<th>28422 (S)</th>
<th>53331 (SE)</th>
<th>49102 (E)</th>
<th>Total</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of active transport/week</td>
<td>127.7</td>
<td>288.3</td>
<td>102.8</td>
<td>246.9</td>
<td>169.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Minutes of total walking/week</td>
<td>227.6</td>
<td>541.7</td>
<td>198.4</td>
<td>291.0</td>
<td>291.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Minutes of total physical activity/week</td>
<td>445.6</td>
<td>856.2</td>
<td>404.4</td>
<td>797.8</td>
<td>568.2</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Weekly minutes of active transport, total walking, and total physical activity were not normally distributed. Due to the substantial negative skewness, a log transformation of the data was performed. This did not result in a normal distribution (see Table 6). A Box-Cox transformation was also performed but did not result in normal distribution (see Table 7). Due to the non-normal distribution, a spearman rank correlation test was computed to assess the relationship between perceived neighborhood design characteristics and minutes of physical activity through active transport alone, total walking, and total physical activity. Correlations show the direction and strength of the relationship between the two variables. There were no statistically significant correlations between perceived neighborhood design characteristics and minutes of physical activity, therefore, any correlation was likely due to chance alone. Table 8 contains all correlation coefficients.
Table 6

*Log transformation of weekly minutes of active transport, total walking, and total physical activity*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of active transport/week</td>
<td>-0.19</td>
</tr>
<tr>
<td>Minutes of total walking/week</td>
<td>-0.95</td>
</tr>
<tr>
<td>Minutes of total physical activity/week</td>
<td>-1.63</td>
</tr>
</tbody>
</table>

Table 7

*Box-Cox transformation of weekly minutes of active transport, total walking, and total physical activity*

<table>
<thead>
<tr>
<th>Activity</th>
<th>Skewness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minutes of active transport/week</td>
<td>-0.19</td>
</tr>
<tr>
<td>Minutes of total walking/week</td>
<td>2.71</td>
</tr>
<tr>
<td>Minutes of total physical activity/week</td>
<td>4.35</td>
</tr>
</tbody>
</table>
Table 8
Correlations between perceived neighborhood design characteristics and weekly minutes of physical activity

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Weekly minutes of active transport $(\rho)$</th>
<th>Weekly minutes of total walking $(\rho)$</th>
<th>Weekly minutes of total physical activity $(\rho)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lack of shade prevents walking for active transport</td>
<td>0.10</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Lack of shade prevents walking for pleasure</td>
<td>0.06</td>
<td>0.10</td>
<td>0.04</td>
</tr>
<tr>
<td>Single entry communities prevent walking for active transport</td>
<td>0.00</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td>Single entry communities prevent walking for pleasure</td>
<td>0.06</td>
<td>0.16</td>
<td>-0.03</td>
</tr>
<tr>
<td>Distance between crosswalks prevent walking for active transport</td>
<td>0.04</td>
<td>0.05</td>
<td>0.00</td>
</tr>
<tr>
<td>Distance between crosswalks prevent walking for pleasure</td>
<td>0.13</td>
<td>0.13</td>
<td>0.10</td>
</tr>
<tr>
<td>Number of high speed streets prevent walking for active transport</td>
<td>0.04</td>
<td>0.05</td>
<td>0.09</td>
</tr>
<tr>
<td>Number of high speed streets prevent walking for pleasure</td>
<td>0.11</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Retail floor area ratio prevents walking for active transport</td>
<td>0.04</td>
<td>0.04</td>
<td>-0.01</td>
</tr>
<tr>
<td>Retail floor area ratio prevents walking for pleasure</td>
<td>0.04</td>
<td>0.00</td>
<td>-0.03</td>
</tr>
<tr>
<td>Land use mix prevents walking for active transport</td>
<td>0.03</td>
<td>-0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Land use mix prevents walking for pleasure</td>
<td>0.05</td>
<td>-0.04</td>
<td>-0.01</td>
</tr>
<tr>
<td>Street connectivity prevents walking for active transport</td>
<td>-0.02</td>
<td>-0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>Street connectivity prevents walking for pleasure</td>
<td>0.04</td>
<td>0.02</td>
<td>0.07</td>
</tr>
<tr>
<td>Residential density prevents active transport</td>
<td>0.16</td>
<td>-0.01</td>
<td>0.11</td>
</tr>
<tr>
<td>Residential density prevents walking for pleasure</td>
<td>0.15</td>
<td>0.01</td>
<td>0.06</td>
</tr>
<tr>
<td>Convenient access to transit result in greater amounts of walking</td>
<td>0.12</td>
<td>0.08</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* = p < 0.05
Minutes of physical activity were transformed into whether or not recommended levels of weekly physical activity were met (150 minutes or more per week) due non-normal distribution. For total physical activity, minutes of vigorous activity were multiplied by 2, as only 75 minutes of vigorous activity are needed to meet weekly recommendations (Centers for Disease Control and Prevention (CDC), 2011b). The percentages of respondents who met the recommendations are listed in Table 9. It is important to note that the percent of survey respondents who meet the recommended levels of physical activity is higher than the U.S. average of 51.6% and the Clark County, NV average of 49.1%.

Table 9

<table>
<thead>
<tr>
<th>Percent of respondents who meet the recommended levels of physical activity</th>
<th>32305 NW</th>
<th>28422 S</th>
<th>53331 SE</th>
<th>49102 E</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meets levels with active transport</td>
<td>28.6</td>
<td>43.3</td>
<td>21.1</td>
<td>35.0</td>
<td>29.6</td>
</tr>
<tr>
<td>Meets levels with total walking</td>
<td>54.3</td>
<td>60.0</td>
<td>42.1</td>
<td>45.0</td>
<td>49.3</td>
</tr>
<tr>
<td>Meets levels with total physical activity</td>
<td>77.1</td>
<td>76.7</td>
<td>70.7</td>
<td>90</td>
<td>76.2</td>
</tr>
</tbody>
</table>

Logistic regression analysis was performed to determine if perceived walkability was associated with a greater likelihood of meeting the recommended levels of physical activity. Perceived measures of walkability were combined into a 3-interval scale of agree, neutral, and disagree. Composite variables were constructed as to not over fit the model due to the small sample size. The two composite independent variables are the perceived urban design characteristics variable and the perceived standard index variable. The perceived urban design characteristics variable is a sum of the 17 3-interval scale responses to the four perceived
standard walkability index characteristics and the five urban design characteristics unique to LVMA. To ensure that these items correlated, a reliability analysis was conducted; Chronbach’s alpha = 0.91 indicating a reliable scale.

The perceived urban design characteristics variable is a summation of the following variables:

- Large parking lots prevent walking for pleasure
- Large parking lots prevent walking for AT
- Poor land use mix prevent walking for pleasure
- Poor land use mix prevent walking for AT
- Poor street connectivity prevents walking for pleasure
- Poor street connectivity prevents walking for AT
- Poor residential density prevents walking for pleasure
- Poor residential density prevents walking for AT
- Lack of shade prevents walking for pleasure
- Lack of shade prevents walking for AT
- Single entry communities prevents walking for pleasure
- Single entry communities prevents walking for AT
- Distance between crosswalks prevent walking for pleasure
- Distance between crosswalks prevent walking for AT
- High speed streets prevent walking for pleasure
- High speed streets prevent walking for AT
- Convenient access to transit result in greater amounts of walking

Logistic regression analysis was performed to determine if the perceived urban design characteristics predicted meeting the recommended levels of physical activity through 1) active transport alone, 2) total walking and 3) total physical activity.

Logistic regression results with the perceived urban design characteristics variable predicting meeting the recommended levels of physical activity through active transport alone are listed in Table 10. The model was not statistically significant, indicating that perceptions of all measured urban design characteristics did not predict meeting the recommended levels of physical activity through active transport. Table 10 shows the results of logistic regression with
the perceived urban design characteristics predicting meeting the recommended levels of physical activity through total walking. The model was not statistically significant, indicating that perceptions of all measured urban design characteristics did not predict meeting the recommended levels of physical activity through total walking. The logistic regression model with the perceived urban design characteristics predicting meeting the recommended levels of physical activity through total physical activity was not significant (Table 10). This indicates that perceptions of all measured urban design characteristics did not predict meeting the recommended levels of physical activity through total physical activity.

Table 10

*Logistic regression to predict relationship between meeting physical activity recommendations and perceived urban design characteristics*

<table>
<thead>
<tr>
<th>variable</th>
<th>Meets recommendations through AT</th>
<th>Meets recommendations through total walking</th>
<th>Meets recommendations through total physical activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>Wald</td>
<td>p-value</td>
</tr>
<tr>
<td>Perceived urban design characteristics</td>
<td>1.03</td>
<td>1.91</td>
<td>0.17</td>
</tr>
</tbody>
</table>

The perceived standard index variable is a composite of the responses to the questions regarding the four perceived neighborhood design characteristics that are included in the standard walkability index. To ensure that these items correlated, a reliability analysis was conducted; Chronbach’s alpha = 0.86 indicating a reliable scale.

The perceived standard index variable is a summation of the following variables:

- Large parking lots prevent walking for pleasure
- Large parking lots prevent walking for AT
- Poor land use mix prevent walking for pleasure
- Poor land use mix prevent walking for AT
- Poor street connectivity prevents walking for pleasure
- Poor street connectivity prevents walking for AT
- Poor residential density prevents walking for pleasure
- Poor residential density prevents walking for AT

Logistic regression analysis was performed to determine if the perceived standard index predicted meeting the recommended levels of physical activity through 1) active transport alone, 2) total walking and 3) total physical activity. Table 11 shows the results of logistic regression with the perceived standard index predicting meeting the recommended levels of physical activity through active transport alone. The model was not statistically significant, indicating that perceptions of the standard walkability index characteristics did not predict meeting the recommended levels of physical activity through active transport. Logistic regression results for the perceived standard index predicting meeting the recommended levels of physical activity through total walking are shown in Table 11. The model was not statistically significant, indicating that perceptions of the standard walkability index characteristics did not predict meeting the recommended levels of physical activity through total walking. The logistic regression model with the perceived standard index predicting meeting the recommended levels of physical activity through total physical activity was not significant (Table 11). The model was not statistically significant, indicating that perceptions of the standard walkability index characteristics did not predict meeting the recommended levels of physical activity through total physical activity.
Table 11

Logistic regression to predict relationship between meeting physical activity recommendations and perceived standard index

<table>
<thead>
<tr>
<th>variable</th>
<th>Meets recommendations through AT</th>
<th>Meets recommendations through total walking</th>
<th>Meets recommendations through total physical activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OR</td>
<td>Wald</td>
<td>p-value</td>
</tr>
<tr>
<td>Perceived standard index</td>
<td>1.04</td>
<td>0.92</td>
<td>0.33</td>
</tr>
</tbody>
</table>

Adjustment for Single Entry Communities.

After adjusting for the presence of single entry communities by removing intersections located within the communities, a paired t-test revealed there was a statistically significant decrease in the number of true intersections after the adjustment (before M=57.8; after M=45.7). The eta squared statistic indicates a large effect size (0.3). This shows that without the adjustment of intersections within single entry communities, the number of intersections is significantly greater. Results are shown in Table 12.
Table 12

*Number of intersections in LVMA neighborhoods before and after accounting for single entry communities*

<table>
<thead>
<tr>
<th>Neighborhood</th>
<th>Intersections Before</th>
<th>Intersections After</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>36</td>
<td>34</td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>40</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>22</td>
</tr>
<tr>
<td>5</td>
<td>194</td>
<td>120</td>
</tr>
<tr>
<td>6</td>
<td>64</td>
<td>25</td>
</tr>
<tr>
<td>7</td>
<td>40</td>
<td>24</td>
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<tr>
<td>8</td>
<td>36</td>
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</tr>
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<td>10</td>
<td>49</td>
<td>44</td>
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<td>11</td>
<td>42</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>13</td>
<td>45</td>
<td>45</td>
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<tr>
<td>14</td>
<td>55</td>
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</tr>
<tr>
<td>15</td>
<td>59</td>
<td>59</td>
</tr>
<tr>
<td>16</td>
<td>67</td>
<td>40</td>
</tr>
<tr>
<td>17</td>
<td>55</td>
<td>34</td>
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<td>18</td>
<td>27</td>
<td>16</td>
</tr>
<tr>
<td>19</td>
<td>156</td>
<td>156</td>
</tr>
<tr>
<td>20</td>
<td>57</td>
<td>57</td>
</tr>
</tbody>
</table>
Chapter 5

Discussion

The aim of this study was to determine what built environment characteristics are associated with walking and physical activity in LVMA. Residents of four neighborhoods were surveyed on their weekly minutes of active transport, leisure walking, vigorous and moderate physical activity, and perceptions of neighborhood design characteristics as barriers to walking.

Survey results indicated that residents perceived neighborhood design characteristics as a barrier to walking, supporting hypothesis 1. Specifically, lack of shade seems to be a barrier in most neighborhoods, as nearly 50% of respondents reported that it prevents them from walking for pleasure and 40% reported that it prevents them from walking for active transport. Poor land use mix and street connectivity were both reported by a large percentage of respondents as a barrier to both forms of walking. There were some notable differences in percentage of agreement between neighborhoods, illustrating that there are some neighborhood designs in LVMA that are less conducive to walking than others. Specifically, there were notable differences between neighborhoods with regard to long distances between crosswalks, high speed streets, poor street connectivity, and poor land use mix as a barrier to walking; and a notable difference between neighborhoods in the percentage of respondents who reported that convenient access to transit would result in greater amounts of walking.

T-tests revealed that there was a statistically significant decrease in the number of true intersections after adjusting for intersections within single entry communities supporting hypothesis 2. This pilot study supports the hypothesis that single entry communities result in an overestimate of street connectivity, which is arguably the most important factor in walkability. Thus, they appear as contributing to intersection density or ‘as the crow flies’ route choices, when in actuality they do not.
Though it is possible to modify the index by subtracting the number of intersections within single entry communities, this step would require close examination through imagery data and/or ground-truthing to identify such communities. This step is time consuming and certainly not efficient if measuring walkability for large regions or areas such as an entire metropolitan area. Given the large amount of single entry communities in LVMA, manually verifying and removing intersections does not seem feasible.

Results from regression modeling revealed that perceptions of neighborhood walkability were not associated with meeting the recommended levels of physical activity through active transport, total walking, or overall physical activity. Therefore, the null hypothesis cannot be rejected for hypothesis 3. There may be a number of potential reasons for this. It is possible that the urban design of an auto-centric city such as LVMA is so unique that the design features associated with more walking and physical activity in other cities do not have the same effect here. Even after accounting for several unique urban design characteristics predicted to influence walking, an association between the built environment and physical activity could not be found. The standard walkability index, while a useful tool in many traditional metropolitan areas, may not be the correct tool to accurately assess walkability in LVMA (and similar southwest metropolitan areas) due to the unique auto-centric design. Given these findings, it is critical to develop a model for walkability in LVMA.

One main reason that the standard walkability index tool may not be the most effective measure of walkability in LVMA is that the features included in the index may measure the same in theory, however, may not be the same in actual design. For example, land use mix is a measure of the diversity of land use types within a block group. Due to the predominance of single-use zoning, the separation of one land use type from another, and the auto-centric design, a neighborhood with a high land use mix in LVMA may look very different from a
neighborhood in non-southwest metropolitan area. In LVMA it would consist of single family residential development abutted to a block wall with a strip-mall type development of retail, office, restaurants, etc. on the other side. In non-suburban neighborhoods high land use mix looks much different. This is illustrated in Figure 4. The majority of the time this block wall will prevent pedestrian travel directly to the strip-mall resulting in longer trip distances. This design has implications for both convenience and pedestrian safety.

Figure 4. Mixed land use may look different in auto-centric cities when compared to older, non-auto-centric cities

This strip-mall type of development, which is the majority of commercial developments in LVMA, is associated with decreased pedestrian safety. The large amounts of asphalt surrounding the developments are meant to accommodate cars, not people. Dumbaugh & Ray (2009) analyzed 3 years of pedestrian crash data from San Antonio, Texas, to understand how different land uses influenced crash rates. They found a 1.3% increase in total crash incidence and a 1.1% increase in injury crash incidence for each strip-mall type development. Within these strip-mall type developments are often ‘big-box stores’ which are large market areas that draw a significant amount of vehicle traffic (ie: Wal-Mart®, Lowes®, etc.). Each big-box store was
associated with a 15% increase in total crash incidence and a 4% increase in injury crash incidence. In contrast, each pedestrian-scaled commercial and retail use was associated with a 2.2% reduction in total crash incidence and 3.4% reduction in injury crash incidence (Dumbaugh & Rae, 2009). The predominant retail and commercial developments in LVMA are not pedestrian scaled and are designed to accommodate automobiles, not pedestrians.

Residential density is another example of a walkability index feature which may measure the same, but not be truly the same in design. Residential lots in Las Vegas are small in comparison to non-western states (Census Bureau, 2010a). There are a number of reasons for this, including the arid climate which naturally lends itself to small lot sizes, and the growth constriction of the surrounding mountains and federally owned land (R. Lang & LeFurgy, 2007). Consequently, Las Vegas has a high number of people per square mile (Census Bureau, 2010b), which translates into a higher residential density as measured by the standard walkability index. Although the density is high in LVMA, the auto-centric design prohibits capitalization of this density to an environment which encourages walkability.

Another distinguishable characteristic is the ample parking available throughout LVMA. Most traditional cities have a downtown urban core with far less free parking. Though LVMA lacks a true urban core, the largest employment concentration is on the Las Vegas Strip or “The Strip”. Along The Strip are numerous casinos and tourist attractions, as well as ample parking to accommodate visitors who arrive by vehicle. This is in part due to the minimum parking requirements set by local city ordinances. For example, Clark County has a minimum parking requirement for hotels of one space per guest room. Resort hotels with unrestricted gaming (casinos) have additional requirements of one space per 1,000 square feet of casino floor (Clark County, 2000). For example, The Cosmopolitan Casino alone, one of over two dozen Casinos on the strip, contains 3,797 parking spaces. This number is actually 30% fewer than the 5,029
spaces mandated per the minimum parking requirements (Clark County, 2006). In office parks the minimum parking requirements are often determined based on building square footage; however, one study found that building occupancy ranged from 0.5 to 6.0 persons per 1,000 square feet (Cervero, 1988). Given the methods used to determine minimum requirements, it is not surprising that there is often a surplus of parking. Numerous studies have shown that peak parking demands average less than 60% of capacity (Shoup, 1997). To illustrate the overabundance of parking in LVMA, Table 13 provides a comparison of the minimum parking requirements for office space of the City of Las Vegas to Portland, OR and Baltimore, MD.

Table 13

Parking requirements for offices (space per building square footage) for the City of Las Vegas, Portland, OR, and Baltimore, MD.

<table>
<thead>
<tr>
<th>City of Las Vegas</th>
<th>Portland, OR</th>
<th>Baltimore, MD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Minimum:</strong></td>
<td><strong>Minimum:</strong></td>
<td><strong>Minimum: (business districts)</strong></td>
</tr>
<tr>
<td>1 per 300sqft(^1)</td>
<td>1 per 500sqft</td>
<td>1 per 2,000sqft in excess of 50,000sqft</td>
</tr>
<tr>
<td><strong>Maximum:</strong></td>
<td></td>
<td>(downtown commercial)</td>
</tr>
<tr>
<td>1 per 294sqft(^2)</td>
<td></td>
<td>1 per 800sqft in excess of 2,000sqft</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(community, neighborhood, highway commercial)(^3)</td>
</tr>
</tbody>
</table>

Sources: 1 (City of Las Vegas, 1997), 2 (City of Portland, 2011), 3 (Baltimore City, 2012)

Given the vast amount of free parking in LVMA it is exceptionally convenient to travel by car. In cities that were built before the boom of the automobile, or before the practice of minimum parking requirements were common, there is less free parking, and thus driving is less convenient. In order to get people out of their cars it must be either inconvenient to drive, or alternative modes of transportation must be made convenient; ideally there would be a
combination of safe and convenient alternative modes of transportation and a disincentive to travel by private vehicle.

In his book *The high cost of free parking*, Shoup contends that minimum parking requirements inflate the demand for parking and then these inflated demands are used to set minimum requirements. One study examining the cost per parking space in structural garages on the campus of UCLA concluded that the cost of a single space averaged over $23,000 (Shoup, 1997). The cost of free parking is far more than a dollar amount. The vast sea of asphalt used to meet this demand for free parking has contributed to urban sprawl and vehicle greenhouse gas emissions, created an unsafe environment for pedestrians, and is an eyesore on urban design.

It is possible that there is a social stigma attached to active transport and utilization of public transit in LVMA. Studies have shown that the average income for bus commuters is far lower than those who commute by car, and bus ridership decreases as average income increases, while commuter rail use increases with income (Garrett & Taylor, 1999; Pisarski, 1996). In LVMA over 90% of households have access to at least one vehicle (US Census Bureau, 2011), using any other form of transportation may have negative a connotation. Further research is required to determine the perceptions of public transit in LVMA with any certainty.

In a Viewpoints article in the United Nations Journal *Natural Resources Forum*, sustainable transport experts Tom Godefrooij and Mark Kirkels explain that in order to decrease the stigma associated with the non-vehicular travel, the built environment must be designed to make walking and cycling trips safe and convenient, as transit riders are also pedestrians at certain points of their travel (Godefrooij & Kirkels, 2010). As for pedestrian safety, LVMA was ranked the 6th most dangerous city for pedestrians by Transportation for America (Ernst, 2011).

Increasing choices of travel modes in LVMA may influence public transit ridership. Studies have shown that transit riders often perceive light rail as superior to bus service, and
thus prefer that as a mode of travel when compared to bus (Dell'Olio, Ibeas, Dominguez, & Gonzalez, 2012). A study examining mode preference found that if the frequency of service and fares are competitive between the bus and light rail, light rail would attract 6.5% more riders (Dell'Olio et al., 2012). LVMA has not invested in light rail and is the only major metropolitan area in the mountain west not to do so. Investment in light rail would likely improve the entire corridor in a number of ways, including economic development, attracting young talent, reduction in vehicle miles traveled and increases in physical activity. Economic development impacts include an increase of denser urban form around light rail lines, increases in shopping business adjacent to light rail stations, development of new shopping centers, stimulation of development of both city centers and in declining areas, and increases in employment (Babalik, 2000; Crampton, 2006).

Creating this dense urban development is likely to enhance economic development by attracting young talent, the college educated millennial generation. It is known that this population prefers the urban landscape to suburbia, and they are interested in development centered around transit options (The Segmentation Company (TSC), 2006). This generation of young talent report that they choose where they prefer to live first, and look for a job second (The Segmentation Company (TSC), 2006). For the future vitality of LVMA, it is imperative that the urban design be marketable in a way which attracts this population.

Light rail in LVMA could also contribute to improved air quality and health through a reduction of vehicle miles traveled and an increase in active travel. Crampton (2006) examined eight metropolitan areas in Britain and France and found that good access to light rail services did result in reduced car ownership (Crampton, 2006). Further, a study in Charlotte, NC examined individuals pre and post light rail construction and found that the use of light rail to commute to work was associated with a reduction in BMI and 81% reduced odds of becoming
obese over time (MacDonald et al., 2010; MacDonald, Stokes, Cohen, Kofner, & Ridgeway, 2010). The addition of light rail to public transit options in LVMA would have positive economic and environmental implications and result in a more healthy and sustainable community.

This study illustrates that LVMA and similar southwest metropolitan areas are unique in urban design in a way that requires a different approach to strategies aimed at increasing walkability. Increasing walkability is still vital to the health and sustainability of LVMA. For public health efforts to effectively increase walkability in LVMA, it is important to first determine what built environment characteristics are associated with walking. It is equally important to determine what factors would result in the use of public transit. Collaborative efforts between public health professionals, urban planners, and policy makers to develop a model for walkability in LVMA are timely and significant.

Limitations.

A number of important limitations need to be considered. The sample size in this study was relatively small with a total of 147 respondents. The small sample size may have masked significant results due to increases in type II error. It is possible that analysis of with a larger sample size may have yielded results different results supporting the initial hypotheses that perceived neighborhood walkability was associated with minutes of physical activity. Due to the small sample size, the data was not normally distributed. This significantly limits the number of appropriate analysis that can be applied to the data.

The response rate to the survey was 6.5%, which may result in a possible non-response bias. In other words, those who completed the survey may be different than those who did not complete the survey (Armstrong & Overton, 1977). This may result in a lack of generalizability of the study findings and not be representative of the association between neighborhood design characteristics and walking and physical activity behaviors for all of LVMA.
The survey respondents differed from the general LVMA population on educational attainment, with respondents being more educated. Additionally, a greater percentage of survey respondents met the recommendations for physical activity. This is not surprising, as higher educational attainment is a predictor of meeting physical activity requirements. Thus, with the respondents being more educated, there is a greater likelihood that they would meet the recommended levels of physical activity when compared to the general LVMA population. This adds to the non-generalizability of the study findings and may not be representative of all of LVMA residents. Survey respondents were not demographically diverse; the majority were white and female. Past studies have found demographic differences in walking behaviors (Greenberg & Renne, 2005). A more diverse sample may have yielded different results.

Minutes of physical activity were self-reported which may have biased results or played a role in the non-normal distribution. Studies have shown that people overestimate the minutes of physical activity when it is compared to accelerometer-measured minutes. Use of accelerometers to measure physical activity would enhance this project. The use of accelerometers was both cost and time prohibitive.

The standard walkability index was calculated for all seven neighborhoods in LVMA as it was explained in the methods section of the article detailing its development (L. Frank et al., 2010). The two highest and lowest walkability scored neighborhoods were then surveyed based on the index calculated as stated in the methods. Through further personal inquiry with the authors it was discovered that intersection density was to be calculated using km$^2$ as the area rather than acres as was stated in the article. This change in measurement did result in a change in overall walkability scores due to the Z-score standardization. Thus, the four surveyed high and low walkability neighborhoods were not as drastically different per the standard index.
However, the standard index was strictly used for neighborhood selection and analysis and regression modeling utilized perceived measures of walkability.

**Future Research.**

Increasing walkability is still vital to the health and sustainability of LVMA. While the standard walkability index takes into account many built environment features that have been associated with walking, the auto-centric design of LVMA may be so unique that consideration of additional factors are necessary. To better understand walkability in LVMA and similar southwest metropolitan areas, the need for future research is two-fold. First, there is a need to determine what factors are associated with active transport and walking in LVMA; second, to determine what factors would persuade those who travel by private vehicle to utilize alternative modes of transportation.

To determine what factors are associated with active transport and walking in LVMA, intercept surveys may prove useful. Surveying those who are already walking to determine what factors were associated with their decisions to walk would help to inform the model for walkability in LVMA. Surveys that contain open ended questions would be beneficial, as factors unique to LVMA may not be fully captured through already existing survey tools.

Public transit options must be considered in combination with walkability if the intention is to change travel behaviors. It is impracticable to promote active transport alone if the individual needs to commute longer distances than is an acceptable walking distance. Assessment of attitudes toward the transit available in LVMA as well as supports and barriers to utilizing public transit would be beneficial. A survey or focus groups would enable a better understanding. Perceptions of matters of convenience and safety, potential attitudes and bias towards transit use, and supports and barriers for use would help inform a model for walkability in LVMA. It is necessary to understand and address the concerns related to public transit in
order to increase use by those who currently commute by private vehicle. Promotion of alternative modes of transportation through a media campaign might change attitudes and result in increased use.

Surveying individuals who commute by private vehicle and do not use active transport would also prove beneficial. In addition to asking what factors individuals value with regard to walking, the survey should inquire as to what factors would change commuting and travel behaviors from their private vehicle to utilizing active transport and public transit. Understanding what is necessary to change travel behaviors is critical in creating a walkable environment.

Collection of the above stated data would enable a better understanding of walkability in LVMA and enable public health interventions to successfully promote active transportation and public transit. After development of an informed model on walkability, the model should be tested through use of accelerometers rather than self-reported data.

Upon completion of a successful model of walkability in LVMA, it should be incorporated into planning efforts. Planning policies within each jurisdiction should require an assessment of neighborhood walkability and inclusion of design characteristics which are associated with increased walking and physical activity to be incorporated into all new development applications prior to approval. Similarly, such policies would be required for all retrofitting of existing neighborhood structures and design features.

The results of this study reveal that walkability in LVMA and similar southwest metropolitan areas require a different approach. More research is needed to create a model for walkability in LVMA. A built environment which promotes physical activity would create a more sustainable, healthy community.
Appendix A

Complete a 10-minute survey for your chance to win great prizes like Waterford wine glasses, Target gift cards, Zappos gift cards, movie tickets and more!

We want to know about your neighborhood design and how it impacts your decisions about walking. If you are between the ages of 18 and 64, please complete and return the enclosed survey in the postage-paid envelope - or - visit the below website for a brief survey:

English  http://tiny.cc/y11bmw
or
Spanish  http://tiny.cc/bq3bmw

Once the survey is complete you can enter the raffle for a chance to win great prizes! The raffle will take place on January 17, 2013. If you are a winner you will be contacted to claim your prize. Your feedback will be used for a UNLV School of Community Health Sciences research project, which could lead to positive changes in the future walkability of Las Vegas. Thank you for your time and attention!

Completar una encuesta de 10 minutos para tener la oportunidad de ganar premios como copas de vino de Waterford, tarjetas de regalo de Target, entradas de cine y mucho más!

Queremos saber sobre el diseño de su barrio y cómo afecta a sus decisiones a caminar. Si usted está entre las edades de 18 y 64, y gustaría completar una breve encuesta por favor complete y devuelva la encuesta adjunta en la sobre prepagado - o - por favor visite:

En Inglés  http://tiny.cc/y11bmw
O
En Español  http://tiny.cc/bq3bmw

Una vez que haya completado el cuestionario su nombre será incluido en el sorteo, que se llevará a cabo el 17 de enero 2013. Si usted es un ganador nos comunicaremos con usted para reclamar su premio. Sus comentarios se utilizarán para un estudio de la escuela de UNLV School of Community Health Sciences. Los resultados podrían conducir a cambios positivos en haciendo Las Vegas un lugar más caminable. Gracias por su tiempo y atención!
This survey will be used in a research study at UNLV School of Community Health Sciences. The purpose of this research study is to determine how you view the built environment of your neighborhood and how this impacts your decision to walk. This survey will take approximately 10 minutes to complete. Your responses will be kept confidential and cannot be linked back to you personally. Your participation is voluntary; you are free to withdraw your participation from this study at any time. If you do not want to continue, you can simply leave this website.
Upon completion of the study you will be entered into a drawing to win one of many prizes or gift baskets valued at up to $50.

By beginning the survey, you acknowledge that you have read this information and agree to participate in this research, with the knowledge that you are free to withdraw your participation at any time without penalty.
If you have questions or concerns about the study you can contact Michelle Chino at michelle.chino@unlv.edu or Courtney Coughenour at coughen2@unlv.nevada.edu

Esta encuesta será utilizada en un estudio de investigación en la UNLV School of Community Health Sciences. El propósito de este estudio de investigación es determinar la forma de ver el entorno construido de su vecindario y como ésta influye en su decisión de caminar. Esta encuesta le tomará aproximadamente 10 minutos para completar. Sus respuestas serán confidenciales y no se puede vincular de nuevo a usted personalmente. Su participación es voluntaria, usted es libre de retirar su participación de este estudio en cualquier momento. Si no quiere continuar, puede simplemente salir de este sitio web.

Una vez finalizado el estudio se le dará una contraseña y será redirijido a otra página de web diferente donde entrara su nombre e información de contacto que se introducira en un sorteo para ganar uno de los muchos premios o cestas de regalo con valor de hasta $ 50.

Al comenzar la encuesta, usted reconoce que ha leído esta información y de acuerdo en participar en esta investigación, con el conocimiento que usted es libre de retirar su participación en cualquier momento sin penalización. Si usted tiene preguntas o inquietudes sobre el estudio que usted puede ponerse en contacto con Michelle Chino en michelle.chino@unlv.edu o Courtney Coughenour en coughen2@unlv.nevada.edu

Please enter your information below so that we may contact you if you are selected as a winner of one of our great prizes!

Name _________________________________________________

Phone _________________________________________________

Email __________________________________________________

~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
General Information

1. Where is your home located?

___________________________________            ____________________________________
Your street      nearest cross street

2. How long have you lived in this neighborhood?    __________ years   __________ months

3. What is your age?       ___________  years

4. What is your sex? (please mark ONE box)  
   ☐ Male  ☐ Female

5. With which race do you primarily identify? (please mark ONE box)
   ☐ American Indian or Alaska Native  ☐ Native Hawaiian or other Pacific Islander
   ☐ Asian  ☐ White
   ☐ Black of African American  ☐ Some other race
   ☐ Hispanic, Latino, or Spanish origin

6. What is the highest level of education that you have completed?
   ☐ Some High School  ☐ High School graduate
   ☐ Some college  ☐ 2 year college degree (associates)
   ☐ 4 year college degree (BA, BS)  ☐ Post graduate work
   ☐ Master degree  ☐ Doctoral degree
   ☐ Professional degree (MD, JD)

7. Do you have an impairment or health problem that limits your ability to walk? ☐ Yes  ☐ No

8. Do you own a vehicle?  ☐ Yes  ☐ No

9. Do you live in a single entry community (either gated or un-gated communities which have only one entrance in and out of the complex)?  ☐ Yes  ☐ No
We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

**Transportation Physical Activity**

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

1. During the last 7 days, on how many days did you travel in a motor vehicle like a train, bus, car or tram?  
   _______ days per week or None [If none, go to question 3]

2. How much time did you usually spend on ONE of those days traveling in a car, bus, train or other kind of motor vehicle?  
   _____ hours ______ minutes per day

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

3. During the last 7 days, on how many days did you walk for at least 10 minutes at a time to go from place to place?  
   _______ days per week or None [If none, go to question 5]

4. How much time did you usually spend on ONE of those days walking from place to place?  
   _____ hours per day ______ minutes per day

5. Not counting any walking you have already mentioned, during the last 7 days, on how many days did you walk for at least 10 minutes at a time in your leisure time?  
   _______ days per week or None [If none, go to question 7]

6. How much time did you usually spend on ONE of those days walking in your leisure time?  
   _____ hours per day ______ minutes per day

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

7. Not counting any walking you have already mentioned, during the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?  
   _______ days per week or None [If none, go to question 9]

8. How much time did you usually spend doing **vigorous** physical activities on one of those days?  
   _____ hours per day ______ minutes per day
Think about all the moderate activities that you did in the last 7 days. Moderate activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

9. During the last 7 days, on how many days did you do moderate physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis?

_______ days per week or [ ] none [If none, go to question 11]

10. How much time did you usually spend doing moderate physical activities on one of those days?

______ hours per day ______ minutes per day

We would like to find out more information about the way you feel or perceive your neighborhood. We’d like to know how each of these impacts your decision to walk. Walking for pleasure refers to any walking you may do for the purpose of exercise, sport, or enjoying the outdoors; walking from place to place refers to any walking you may do secondary to other activities, such as going to work, the store, or running errands. Using the 1 – 6 scale below, please circle the answer that best applies to you and your neighborhood.

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>11a. There are not enough trees that provide shade cover in my neighborhood which keep me from walking for pleasure during the summer months.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11b. There are not enough trees that provide shade cover in my neighborhood which keep me from walking from place to place during the summer months.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12a. There are multiple single entry communities in my neighborhood (either gated or un-gated communities which have only one entrance in and out of the complex) which keep me from walking for pleasure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12b. There are multiple single entry communities in my neighborhood (either gated or un-gated communities which have only one entrance in and out of the complex) which keep me from walking from place to place.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13a. The long distance between crosswalks on major streets in my neighborhood keep me from walking for pleasure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13b. The long distance between crosswalks on major streets in my neighborhood keep me from walking from place to place.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14a. The presence of high speed, multiple lane streets in my neighborhood keep me from walking for pleasure.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14b. The presence of high speed, multiple lane streets in my neighborhood keep me from walking from place to place.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>strongly disagree</td>
<td>disagree</td>
<td>somewhat disagree</td>
<td>somewhat agree</td>
<td>agree</td>
<td>strongly agree</td>
</tr>
<tr>
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</tr>
<tr>
<td>15a. The retail areas and stores in my neighborhood have large parking lots and are not pedestrian friendly which keep me from walking for pleasure.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>15b. The retail areas and stores in my neighborhood have large parking lots and are not pedestrian friendly which keep me from walking from place to place.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>16a. There is not a good mix of stores and facilities (ie: entertainment/restaurants, retail, offices, schools) in my neighborhood which keep me from walking for pleasure.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>16b. There is not a good mix of stores and facilities (ie: entertainment/restaurants, retail, offices, schools) in my neighborhood which keep me from walking from place to place.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>17a. There are not many alternative routes for getting from place to place in my neighborhood (I have to go the same way every time because the streets are not well connected) which keep me from walking for pleasure.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>17b. There are not many alternative routes for getting from place to place in my neighborhood (I have to go the same way every time because the streets are not well connected) which keep me from walking from place to place.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>18a. There are not many housing units (houses, townhomes, and apartments/condos) and/or the housing units are too spread apart in my neighborhood which keep me from walking for pleasure.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>18b. There are not many housing units (houses, townhomes, and apartments/condos) and/or the housing units are too spread apart in my neighborhood which keep me from walking from place to place.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>19. If it was convenient to access to public transit (ie: bus stops) in my neighborhood, I would walk more often.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

Congratulations, you’re finished!!! Please insert in the pre-addressed, postage-paid, return envelope. Don’t forget to fill out your contact information on page 2 to be entered into the drawing for great prizes such as Waterford wine glasses, Zappos gift cards, movie tickets, and more!
Appendix B

COMPLETE A 10-MINUTE SURVEY FOR YOUR CHANCE TO WIN GREAT PRIZES LIKE WATERFORD WINE CLASSES, TARGET GIFT CARDS, ZAPPOS GIFT CARDS, MOVIE TICKETS AND MORE!

We want to know about your neighborhood design and how it impacts your decisions about walking. If you are between the ages of 18 and 64, please visit the below website for a brief survey:

English
http://tiny.cc/y1tnmw

Spanish
http://tiny.cc/bq3twnw

Once the survey is complete you can enter the raffle for a chance to win great prizes! The raffle will take place on January 17, 2013. If you are a winner you will be contacted to claim your prize. Your feedback will be used for a UNLV School of Community Health Sciences research project, which could lead to positive changes in the future walkability of Las Vegas. Thank you for your time and attention!

COMPLETE LA ENCUESTA DE 10 MINUTOS PARA TENER LA OPORTUNIDAD DE GANAR PREMIOS COMO COPAS DE VINO DE WATERFORD, TARJETAS DE REGALO DE TARGET, ENTRADAS DE CINE Y MUCHO MAS!

Queremos saber sobre el diseño de su barrio y cómo afecta sus decisiones para caminar. Si usted está entre las edades de 18 y 64, y gastará la completar una breve encuesta por favor visite:

En inglés
http://tiny.cc/y1tnmw

En Español
http://tiny.cc/bq3twnw

Una vez que haya completado el cuestionario su nombre será incluido en el sorteo, que se llevará a cabo el 17 de Enero del 2013. Si usted es un ganador nos comunicaremos con usted para reclamar su premio. Sus comentarios se utilizarán para un estudio de la Universidad de UNLV School of Community Health Sciences. Los resultados podrían conducir a cambios positivos para hacer Las Vegas un lugar más caminable. Gracias por su tiempo y atenciòn!
References


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EDUCATION

University of Nevada, Las Vegas (Las Vegas, NV) 2013
PhD, Public Health, Social and Behavioral Health

University of Nevada, Las Vegas (Las Vegas, NV) 2009
Master of Public Health, Environmental and Occupational Health

Pennsylvania State University (University Park, PA) 2005
Bachelor of Science, Biobehavioral Health

PROFESSIONAL EXPERIENCE

UNLV Urban Sustainability Initiative
Graduate Assistant (Las Vegas, NV) 2009 - present
- Conducted various research in the area of Health & Place. Calculated the walkability of Las Vegas neighborhoods and assessed the association between walkability, unique urban design characteristics and physical activity. Examined the association of environmental and social correlates on youth physical activity levels at parks. Examined the association of environmental and social correlates on pedestrian injury. Examined access disparities in low income and minority areas to parks, trail heads, and walkable neighborhoods.

Consultant for the City of Henderson (Henderson, NV) 2012 - present
- Co-authored a document assessing the existing conditions surrounding numerous areas of sustainability for the Las Vegas Metropolitan area; duties included data collection, mapping, data analysis, and narrative development. Topic areas include demographics, housing, transportation, environment, energy, water, infrastructure, economic development and health and community services. Serve on the Healthy Communities and Spatial Analysis task groups. Reviewed various Statement of Qualification (SOQ) packets for potential new consultant hires.

B.A.S.I.C.S. International
Health Educator (Accra, Ghana, West Africa) 2010
- Created a didactic and game-based HIV education program specific to Ghanaian youth; implemented the program to youth aged 10 to 22 years over a four week period; evaluated the program and drafted a report on findings.
School of Community Health Sciences, Dept. of Environmental and Occupational Health
Graduate Assistant (Las Vegas, NV) 2007 - 2009
- Completed a study on the survivability of Methicillin-Resistant \textit{Staphylococcus aureus} (MRSA) on five different environmental surfaces under two different humidities, with and without the addition of bovine serum albumin; executed microbiological examinations on clinical and environmental specimens for the detection and identification of microbial agents of disease; performed quality control measures and routine maintenance on equipment.

Research and Data Coordinator (New York, NY)
- Responsible for the collection of data on all assisted reproductive technology which is reported to the CDC.

TEACHING EXPERIENCE

UNLV School of Community Health Sciences
Introduction to Public Health, PBH 205 (web-based) Fall 2012, Fall 2011
Health Studies of Dangerous Drugs, PBH 435/HED 635 Spring 2012, Spring 2013

PRESENTATIONS

American Public Health Association Annual Conference 2012
- \textit{Evaluating the influence of environmental and social determinants of physical activity in low income neighborhood parks in Clark County, NV.}
- \textit{Examining access to trails in high and low income regions of the Las Vegas Metropolitan area.}

Nevada Public Health Association Annual Conference 2012
- \textit{Is there a disparity in park access in Clark County, NV?}
- \textit{An examination of walkable neighborhoods in the Las Vegas Metropolitan area.}
- \textit{Examining access to trails in high and low income regions of the Las Vegas Metropolitan area.}

ACSM National Strategic Summit 2012
- \textit{Do environmental and social determinants predict physical activity levels in neighborhood parks in Las Vegas, NV?}
American Public Health Association Annual Conference 2011

- Evaluating the Impact of Social Determinants on Pedestrian Injury in Clark County, Nevada.

Nevada Public Health Association Annual Conference 2010

- Implementing an HIV Prevention Program for Ghanaian Youth in a Low Income Fishing Community in Greater Accra.

Publications


Certifications and Professional Organizations

- American Public Health Association 2011 - present
- Nevada Public Health Association 2009 - present
- American College of Sports Medicine 2012 - present
- Nevada Environmental Health Association 2012 - present
- Association of Pedestrian and Bicycle Professionals 2012
- UNLV, Graduate and Professional Student Association 2007 – 2009

Grants Received

- UNLV Graduate and Professional Student Association 2010
  Implementation of an HIV education program in Accra, Ghana
- Urban Sustainability Initiative 2010
  UNLV Public Health curriculum development of sustainability-related courses