THE EFFECTS OF THE PHYSICAL ENVIRONMENT ON PHYSICAL ACTIVITY OF OLDER ADULTS

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by
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ABSTRACT

With obesity-related health problems on the rise among older Americans in the past few decades, physical activity has been a major focus in the fight to overcome the obesity epidemic. The evidence to date suggests that the built environment, specifically walkable neighborhoods and features, is associated with physical activity among all ages.

This study examined the associations between environmental walkability and physical activity levels of older adults, and compared the data in two different areas of two cities: the downtown and suburban-rural sites of San Diego, CA and Ithaca, NY.

Results indicate similar physical activity levels among older adults in objectively walkable, downtown sites versus less walkable, suburban/rural sites, and suggest perceived neighborhood environment and personal factors as particularly significant factors. Specifically, neighborhoods that were perceived to have high diversity of land use mix, aesthetic attributes, and walking and cycling facilities were significantly associated with higher physical activity. Recommendations are also given regarding the importance of examining other factors such as weather, acculturation, walking purpose, and travel mode, to further understand the complexity of the relationship between the physical environment and older adults’ physical activity.

KEY WORDS: Older adults, Physical activity, Environment, Walkability
BIOGRAPHICAL SKETCH

Annie Jieun Lee was born in Chicago, Illinois on February 4th, 1982 and moved to California two years later. She attended grades K-12 in Southern California before she attended Cornell University from 2000 to 2004. Annie graduated with a Bachelor of Science degree in Design and Environmental Analysis (DEA). She completed Cornell Graduate School the following year studying Human Environment Relations in the same field of DEA, with a minor in Human Development. She is continuing to explore the design field, currently working for an international lighting design firm in New York City.
I would like to first thank Nancy Wells, my thesis advisor, and Elaine Wethington, my minor chair. Nancy has worked with me so closely from the start, since the summer of 2004. She has helped me in every step of the research process, lending her knowledge and challenging me with new perspectives on environment research. No obstacle was too big or too small for her to offer her time and constant encouragement, and for that I am especially grateful. Elaine Wethington has met with me during the school year every Monday to listen to my progress and offer solid advice in data analysis. Even with professors’ schedules, both mentors have been consistently supportive – be it in person, over the phone, or email.

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CHAPTER 1-A. INTRODUCTION

How did obesity and inactivity become national epidemics? The answer lies in many factors which include a series of lifestyle changes affecting diet and physical activity, environment, as well as individual differences that have persisted in the older generation. Before we discuss the health consequences of obesity and inactivity, we take a different vantage point – the American lifestyle. In his book, *Fat Land*, Greg Critser (2003) explains in historical detail how American society has gotten so overweight in the past 30 years. He points out the change in lifestyle Americans have experienced that have contributed to the obesity epidemic, including consuming more calories while expending less energy, social factors, and changing health habits.

**Evolution of Food**

In the early 1970s, American diets began to change with the times, and the American population as a whole got heavier. Pressure came from farmers whose cropland and labor was getting more expensive, American consumers demanded lower food prices now, and unstable food prices all led to a food shortage situation in America. Changing consumer trends contributed to one solution: the mass production of high fructose corn syrup (HFCS) sweetened foods. A cheaper sweetener that was substituted in high-sugar products to lower the costs of production, HFCS had other benefits as well: it protected frozen foods from freezer burn, kept products fresh-tasting, gave pastries the just-browned-in-the-oven look, and was six times sweeter than sugar. However, it settled in the liver without going through the normal breakdown process of fructose. Pretty soon, HFCS was a mass produced additive that increased calories in foods. Similarly, palm oil was developed as a significantly cheaper commercialized fat substitute for vegetable oil, and came to be used for everything from frying fries to baking cookies. This also resulted in increased calories for Americans because palm oil is a highly saturated fat (Critser, 20-62).
In addition, poor eating habits in the form of snacking contribute to the country’s trend toward obesity. A particularly convincing piece of evidence on the toll of worsened eating habits on obesity is a graph showing Body Mass Index (BMI) growth vs. growth of new food products classified as condiments, candy, snacks, and bakery foods (Figure 1), (McCrory, Fuss, McCallum, Yao, Vinken, Hays, and Roberts, 1999). BMI is a formula that uses weight and height to determine the weight status of adults, ranging from Underweight to Obese (CDC, 2004)\(^1\). Figure 1 shows the rise of both BMI and increasing number of fructose-laden food products beginning from the late 1970s. Furthermore, consumption data between 1960 and 2000 shows increased amounts of HFCS and soft drinks, and decreasing amounts of milk occurring around the same period as an increasing prevalence of obesity (Zemel, Shi, Greer, et al., 2000).

In the 1980’s, waning fast food companies looked for increased profit and found the answer in the idea of “more for less”: Taco Bell found that increasing meal portions did not result in satiety – in fact, customers ate more. With the value meal concept, supersizing, and increased snacking, there was no limit to expanding people’s hunger, for the presence of larger portions resulted in more eating, and eating less healthy foods.

**Evolution of Society and Environment**

With Americans eating more calories more often, one would have to burn more energy to maintain weight. This is not the case in the ever-more sedentary lifestyle of Western society. While people’s energy consumption was increasing through consumption of energy-dense foods with ingredients like HFCS and palm oil, one’s energy burning level decreased over time due to technological advances that demand

---

\(^1\) The BMI formula:

\[
\text{BMI} = \frac{\text{Weight in pounds}}{\left(\text{Height in inches}\right)^2} \times 703 \quad \text{or} \quad \frac{\text{Weight in Kilograms}}{\left(\text{Height in Meters}\right)^2} \times 100
\]
almost no physical strength or work at all. Nutrition researchers state that individual physical activity and dietary behavior settings in the U.S. are influenced by features that support less healthy choices (Hill, Goldberg, Pate, and Peters, 2001). James Hill, a physiologist at the University of Colorado’s Health Sciences Center, states in an interview that obesity is “a normal response to the American environment,” (Critser, 2003, p. 3).

Due to technology, Americans have become more efficient in their work over the past years, but this means a more physically inactive lifestyle. Increasing work hours in a relatively sedentary occupation have added to the problem. An interesting study on physical activity levels of an Amish community, a group with a low prevalence of obesity, is a reminder of the impact modern technology has had on the
decline in occupational physical activity over the past 150 years (Bassett, Schneider, and Huntington, 2004). The group that was studied lived in Ontario, Canada, and like the rest of the Amish community, refrained from using modern technological advances in their daily lives (Bassett et al., 2004). The study found an average daily step-count of about 18,000 for men and 14,000 steps for women in the Amish participants; their activities included farming and construction work, stove manufacturing, and furniture making in men, and household chores, cooking, selling produce, and caring and feeling farm animals in women (Bassett et al., 2004). Compare these numbers to about 4000 steps for the average American men and women, and it is easy to see why only 4% of Amish adults are obese (Bassett et al., 2004).

Transportation research has also helped us understand the impact of motorized transport on the health and physical inactivity of Americans (Sallis, Frank, Saelens, Kraft, 2004). For the first time, the average U.S. household owns more vehicles than number of drivers: an average of 1.9 personal vehicles, versus the 1.8 drivers, per household (NHTS, 2003). Longer commutes in cars and doing most daily travels by car rather than by foot have also contributed to the sedentary lifestyle. Eighty-three percent of all “trips”, from a point of origin to a destination, were found to be short, for non-work purposes, and occurring close to home, according to the U.S. Department of Transportation (Ross, Dunning, 1997). Frank, Andresen, and Schmid (2004) found that obesity was positively linked with time spent in the car across gender and ethnicity (black and white), and negatively linked with self-reported travels on foot – a 6% increase in odds for obesity for each hour spent in a car per day, and a 4.8% decrease for each kilometer walked.

**Biology’s Role**

Biology also plays a role in the results of our nation’s staggering obesity statistics. Our bodies’ natural tendency has evolved to store excess energy as fat when
it is not used; we do not have a gene or biological drive to increase physical activity when food supply is abundant (Peters, Wyatt, Donahoo, Hill, 2002). The thrifty gene theory, first coined in the 1960s by V. Neel, said that the insulin-resistant gene causes humans to hold on to energy and store it as fat for long periods of scarcity. In a nutritionally poor environment such as Mexico and Central America, the thrifty gene makes sense and is thus programmed in utero to be more effective to the people of these populations. Critser specifically focuses on the U.S’s Latino population because they are a labor-intensive population whose metabolic history, according to anthropologist Barry Bogin, has evolved in a nutritionally poor society due to cultural and political oppression (Critser, pg. 130). Thus, in a culture of abundant (unhealthy) foods like America, their bodies are inclined to store fat.

A common way to think about food is the “energy balance” or “energy in, energy out” idea. According to Hill (2004), in order to avoid obesity, individuals should balance the amount of energy one intakes with how much one expends. However, in Western society where one is not likely to be going without food for a long time and is thus not burning as much energy as one is consuming, there is a mismatch between biology – our metabolism – and environment (Peters, Wyatt, Donahoo, Hill, 2002). Our society has encouraged food intake with tasty, convenient, and cheap foods while sufficient levels of physical activity have not been a requirement for daily living (Peters, et al., 2002). Hill has pinpointed an exact year when all Americans will become obese, if we go at the increasing rate of obesity today, to the year 2050 (Critser, p. 3). Thus in the environment’s perspective, the combination of the body’s natural tendency to store fat, with the increase and low cost of calorie-dense foods and the value Americans have put in getting more for less, it is no wonder that obesity is a rising problem of today.
CHAPTER 1-B. PHYSICAL ACTIVITY AND TODAY’S SOCIETY

Health Disparities and Obesity

Obesity is a growing epidemic that has spread across the U.S. rapidly in the past 20 years (CDC, 2003). According to BMI data collected from 1985 to 2003, every state has gotten fatter. Today, roughly 60 million U.S. adults – or 31% of the general population – are obese, and 9 million are morbidly obese so that they qualify for gastroplasty, a drastic surgical procedure for weight loss (Agency for Healthcare Research and Quality, 2004). In less than 20 years, the prevalence of obesity among adults by state has grown from 4 states with 15-19% obese in 1991, to 46 states with prevalence rates of 15-19% or more in 2003 (CDC, 2003).

So why do increasing BMI trends matter? Obesity and being overweight increases the likelihood of chronic disease risk factors, such as coronary heart disease (CHD); Type II diabetes; endometrial, colon, postmenopausal, breast, and other cancers; asthma and other respiratory problems; osteoarthritis; dementia; and disability (CDC, 2003). In fact, just a 10 pound weight excess increases one’s risk for death, particularly for those between the ages of 30 and 64 years (U.S. Surgeon General, 2001). Premature morbidity, health care costs, loss in productivity, and social stigmatization add to the burdening issue. Obesity and diabetes together are estimated to contribute to over $100 million yearly in cost (U.S. Department of Health and Human Services, 2002). Relative to the normal weight category (BMI 18.5 to <25), obesity, although not being overweight, was found to be associated with excess deaths with a risk greater than 1, even after a supplemental analysis controlled for any systematic biases related to illness-induced weight loss, smoking, and prevalent illness at baseline (Flegal, 2005).
Factors Affecting Obesity

There is abundant data concerning personal factors explaining obesity in Americans. The victims of obesity in the U.S. vary by gender, income, ethnicity, age, location, and other demographic factors, but specific studies indicate that the likelihood of obesity increases with being female and an ethnic minority. Although men are more likely to be overweight than women, older women among the ages 65-74 were more obese in 1999-2002: 32% compared with 27% (CDC Health Risks and Behaviors, 2003). Obesity was also found to be related to the number of children women have had. Risk for obesity increased by 11% with each additional live birth, regardless of socio-economic status and other confounding factors in older women (Bastian, West, Corcoran, Munger, 2005).

For minorities, acculturation is an added determinant in explaining obesity. Acculturation can be measured by the number of years lived in the U.S., generational status, and primary language spoken at home (Hubert, Snider, Winkleby, 2005). Higher acculturation was found to be the strongest correlate of obesity in a sample of U.S. Latino men and women, followed by less exercise and poorer diet (Hubert et al., 2005). Acculturation was found to play a role in participation of leisure time physical activity among Mexican-Americans; those who spoke mainly Spanish at home had the highest prevalence of physical inactivity, followed by those who spoke Spanish and English, and lowest were those who spoke only English (Crespo, Smit, Andersen, Carter-Pokras, Ainsworth, 2000). Belza and colleagues (2004) suggest that because older adults in immigrant communities are likely to stay sedentary, they are at increased risk for obesity.

Socio-economic status (SES) also plays a significant role in the obesity rates, in that women of low SES (income <130 percent of poverty threshold) are 50% more likely to become obese than those of high SES (>130 percent). Men however,
regardless of SES, have an equal chance of becoming obese. Income inequality – the distribution of income within society – has also been studied as a determining factor in health status (Kawachi, Kennedy, 1999). For white women, analysis on longitudinal socio-economic status found a large negative association between BMI and one’s net worth, and a smaller negative association for black women and white males. Furthermore, dramatic improvements in financial position were associated with large amounts of weight loss among men and women (Zagorsky, 2005).

Nevertheless, the threat of obesity is prevalent even among the wealthy who are more likely to have adequate health care, access to health facilities, and are well educated about the risks of overweight and obesity. Recent headlines reported that obesity is growing fastest among Americans who make more than $60,000 a year, which might have connections with disposable income (“Report: Obesity,” 2005).

Physical Activity

Physical activity is an important aspect of obesity prevention, especially if one’s energy intake exceeds energy expenditure (Hill, 2004). Countless studies have been reported on the benefits of physical activity at any age for cardiovascular health, decreased weight gain, weight loss, lower blood pressure, as well as lower odds of chronic illnesses such as Type II diabetes, sleep apnea, and many other concerns derived from obesity (Mokdad, Serdula, Dietz, Bowman, Marks, and Koplan, 1999; Wessel, Arant, Olson, Johnson, Reis, Sharaf, Shaw, Handberg, Sopko, Kelsey, Pepine, and Merz, 2004; Wong, Wong, Pang, Azizah, and Dass, 2003). The American College of Sports Medicine (ACSM) recommends every U.S. adult be physically active for at least 30 minutes a day, five days a week, to maintain health and prevent disease (ACSM, 2003). Improved body composition, decreased CHD factors – blood pressure and total blood cholesterol – and decreased time to complete functional tasks were among the significant variables found in the exercise group. The effect of physical
activity on an individual’s psychological well-being is also positive. Four studies on
the association between physical activity and aspects of mental health show that
physical activity improves general well-being, lowers levels of anxiety and depression,
and is associated with positive mood (Stephens, 1988).

High obesity rates in the U.S., especially prevalent among women, older
adults, and minorities, may have to do with the fact that these populations have a
higher prevalence of physical inactivity. Regardless of age or culture, national data
shows that only 27% of women meet daily recommendations for physical activity
(Crespo, Smit, Andersen, Carter-Pokras, and Ainsworth, 2000; Schoenborn and
Barnes, 2002). Despite the recommendations given by ACSM, most U.S. adults have
not met daily requirements of physical activity. Older adults are the least physically
active, resulting in increased numbers of obese older adults (AARP, 2004). Since
1960-62, the percentage of older Americans aged 65-72 who were overweight or
obese increased from 18% to 55% (Federal Interagency Forum on Aging Related

Minority groups have fallen victim to physical inactivity, as the following
studies have found. One research study found that physical activity is more prevalent
in Caucasian men and women than among African-American men and women age 20
and older in almost all measurements of social class: Education level, Occupation,
Poverty, Employment, and Marital status (Crespo et al., 2000). However, this study
found that Mexican-Americans were the most physically inactive group (Crespo et al.,
2000). Further data surveyed by the CDC and state health departments between 1991
to 1998 have shown the greatest increase in obesity among Hispanics, with an 80%
jump in obesity prevalence from 11.6% in 1991 to 20.8% in 1998 (Mokdad, Serdula,
Dietz, Bowman, Marks, and Koplan, 1999). In 2002, Eyler reported that national data
on physical inactivity prevalence for Native American and Asian-American/Pacific
Islanders were not known, and Evenson, Wilcox, Pettinger, Brunner, King, and McTiernan (2002) called for more research regarding physical activity among Hispanic, Asian/Pacific Islander, and American Indian groups. Recently, Kandula and Lauderdale (2005) found that Asian-Americans, especially immigrants, are at risk for low levels of leisure-time physical activity (LTPA) and high levels of physical inactivity. LTPA is defined as any type of physically active hobbies, sports, or exercises (Crespo, Keteyian, Heath, and Sempos, 1996). Kandula et al. (2005) suggests that cultural barriers, such as length of residence in the U.S. and use of English at home, may be associated with meeting recommended levels of LTPA. Conversely, the report also states that risk for chronic diseases increase as Asians live in the US longer (Kandula et al., 2005).
The Benefits of Physical Activity for Older Adults

Over the past decade, we have expanded our knowledge of how older adults benefit from physical fitness (Buchner, 2003). Studies show that low to high-intensity forms of physical activity make a difference in older adults’ quality of life by improving many aspects of physical and mental health as well as self-efficacy and independence (Booth, Owen, Bauman, Clavisi, and Leslie, 2000; Resnick, 2000; Keysor, 2003; Lim, Taylor, 2005). Epidemiological research has found that physical activity has modest effects in fitness among older adults, and has more meaningful effects on functional limitations (Buchner, 2003). Through reducing functional limitations and disability, physical activity is tied to the prevention of other diseases as well, including cardiovascular, arthritis, and of course, obesity (Buchner, 2003).

Weight Management

Studies show that physical activity is a core component of long-term weight management at any weight, even among overweight or obese older adults (Blair and Church, 2004). One study showed that a 12-week intervention of twice-weekly exercise sessions for overweight older women was effective in improving performance in physiological functions and enhancing life satisfaction (Grant, Todd, Aitchison, Kelly, Stoddart, 2003). Another study of older women concluded that those who were physically active and overweight or obese had similar physical function levels as those who were normal-weight (Brach, VanSwearingen, FitzGerald, Storti, Kriska, 2004).

Physical Function

Improved function is extremely important for older adults whose bodies are aging and unfortunately, physically working against them. Physical activity helps maintain functional performance and health by reducing functional limitations.
Evidence suggests that chair rise transfers, a common functional activity, improved with older adults in exercise or resistance programs (Keysor, 2003). Another study involving older adults with osteoarthritis has found improvements with exercise programs on self-reported physical function and performance-based measures as well (Baker, Nelson, Felson, Layne, Sarno, Roubenoff, 2001).

Mental Health

Mental health benefits of physical activity among older adults have also been associated with physical activity as well, where physically active older women were 50% less likely to be depressed and anxious than those who were inactive (Cassidy, Kotynia-English, Acres, Flicker, Lautenschlager, Almeida. 2004). Physical activity also was found to prevent against cognitive decline in older women (Yaffe, Barnes, Nevitt, Lui, Covinsky, 2002). Evidence from a Japanese study also found fewer depressive symptoms in older adults who walked daily at the 2-year follow up (Fukukawa, Nakashima, Tsuboi, Kozakai, Doyo, Niino, Ando, Shimokata 2004).

Preventing Injury

Safety is extremely important for older adults who are prone to falling and severely injuring themselves. Several studies show that exercise that focuses on balance training contributes to the prevention of falls and injuries and in addition improving confidence. One randomized controlled study on older adult women 80 years and older found that participants that continued with the exercise group were more confident in their first year about not falling, were more likely to be the ones who had fallen previous, and were more physically active to begin with (Campbell, Robertson, Gardner, Norton, Buchner, 1999). The group, which participated in walking and strength and balance training, also had a significantly reduced risk of falls over a 2-year period (Gardner et al., 1999). Strength training also helps increase strength of muscles, maintaining bone mass, preventing arthritis, and improving
balance, coordination, and mobility (CDC, 2005). Buchner (2003) identifies the need for more research of physical activity’s health effects on dementia and stroke, the major causes of disability in older adults.

**Why Most Older Adults are not Physically Active**

Despite the benefits of activity, most older adults are not active at all. There are a variety of reasons why the majority of this population does not engage in regular physical activity. These include personal factors such as age, gender, and ethnicity; perceptions of physical activity; and self-efficacy, which integrates cognitive-behavioral factors (Keysor, 2003).

*Personal Factors*

The aging process raises concerns on the expectations and ability to be active in this population, because physical activity naturally declines with age and physical functioning. Statistics show that older adults are the least physically active of any age group, with about 35% of those 65 and older not engaging in any leisure-time physical activity (Federal Interagency Forum on Aging Related Statistics, 2004). About 60% of those 65+ are completely inactive and participate in no physical activity (AARP, 2004). Furthermore, 50% of older adults who are not physically active do not plan to start a regular exercise program (Dishman, Sallis, 1994). The older one gets, the less likely it is that he/she will engage in the recommended physical activity 30 minutes, 5 days a week; only 12% of those aged 75 and over follow these recommendations. One exception was found in a study of Australian older adults by Booth and colleagues (2000) that reported the highest level of physical activity among the 65-69 age group, which was greater than the 60-64 or 70 and older age groups. Speculations include reasons related to retirement and more time for leisure activities (Booth et al., 2000).

Studies have also shown gender to be a large factor in physical activity; Booth and colleagues (2000) found that males were more active than females – 55% vs. 38%.
Older women are one of the least active groups in the U.S., with 51% of those aged 65-74 reporting no leisure-time activity, and a higher percentage among those aged 75 and up (Schoenborn, Barnes, 2002). Being male is the second strongest association with adequate physical activity among older adults (Lim et al., 2005). Thus, in 1999-2002, 32% of older women aged 65 and older were obese, compared with 27% of men (Federal Interagency Forum on Aging Related Statistics, 2004). However, older men are more likely to be overweight – 73% of men versus 63% of women. A main reason why physical activity might be dependent on gender among older adults is raised by Resnick’s (2001) study where gender was found to have a statistically significant relationship with self-efficacy expectations, with males being more likely to have stronger self-efficacy expectations related to exercise (Resnick, 2001). Resnick (2001) proposes that this is because older men had past experiences with exercise and are thus more likely to feel confident than older women who were not encouraged to exercise when they were younger.

Ethnicity is another variable found to be associated with engaging in adequate physical activity, where minorities – particularly African-American, Hispanic, and Native American older women – have lower levels. According to the 1997-1998 National Health Interview Survey, 55% of African-American women and 57% of Hispanic-American women are physically inactive (Schoenborn et al., 2002). Crespo’s study on U.S. Latinos, Caucasian persons age 70-79 had a lower prevalence of physical inactivity than any age group of both Mexican-American men/women. Other studies show minority women to be the more physically inactive subgroup of Americans, the lowest among African Americans and American Indians/Alaskan Natives (Brownson, Eyler, King, Brown, 2000). Predictably, a cohort study following participation in vigorous activity of multiethnic older women found that the
prevalence of vigorous activity declined with age, largely from age 50 to the current age (Evenson, Wilcox, Pettinger, Brunner, King, McTiernan, 2002).

Perceptions of Physical Activity

One reason for the reluctance to be active could be that older adults view “exercise” as something that they cannot physically do. An American Association for Retired Persons (AARP) study (2004) raised the importance of terminology distinguishing “physical activity” and “exercise”, and found that in general, older adults thought of exercise as planned and purposeful, and thus sometimes a daunting task. Instead, older adults preferred “physical activity” because it implied more everyday things one does in a busy, active life. The AARP study (2004) also emphasized the appeal of activities that can be done at home, such as walking. Older adults’ dependence on their cars may be another reason for the lack of physical activity. According to the Federal Highway Administration (1997), more than 90% of all trips made by older adults are by car.

Self-Efficacy

Among those who know the benefits of physical activity on health, another factor that may determine participation in physical activity is self-efficacy or motivation. According to Bandura (1997), self-efficacy expectations are influenced by four sources of information: performance accomplishment; verbal encouragement; vicarious experience, or seeing similar individuals engaging in the activity; and affective states, or the sensations experienced during the activity. Previous research through AARP (2004) supports this proposition in that older adults find it motivating to see images that they can relate to, but they need acknowledgement and encouragement, especially from physicians or health professionals. In Resnick’s study (2001), physical health and prior exercise experience were found to be directly associated with self-efficacy expectations. Rejeski, Ettinger, Martin, and Morgan
(1998) found that self-efficacy was a mediator in the effect of exercise on stair-climbing times, and self-efficacy increased with exercise among older adult participants with knee osteoarthritis.

Health knowledge varies among different groups of older adults, but the majority in the AARP study (2004) knew very well the benefits and they should be exercising, although acting upon that knowledge is difficult for a variety of reasons. The AARP research (2004) concluded that older adults would like more information on how to exercise safely, stay motivated, and set realistic goals.

**Walking as a Solution**

Whether an older adult engages in physical activity or not is also largely determined by the type of activity, as well. Physical activity research has divided activities into two main types: utilitarian and recreational (Saelens, Frank, Sallis, Kraft, 2003). Studies of physical activity purpose have found more opportunities for researching what affects physical activity behavior. Utilitarian activities, also called “non-motorized transport”, are those that are performed within our daily routines, such as walking or biking to do errands, and recreational is exercise as a means to an end. Meaningful activities are thus tied with utilitarian activities; people find more meaningful those activities which have a purpose, connect them to their past, or are enjoyable (Frank, Engelke, Schmid, 2003).

Walking is a common utilitarian activity that can be the solution to decreasing the amount of obese people in the U.S. Walking for exercise is beneficial to health, but there are other reasons to specifically encourage this mode of exercise: 1) walking is the most popular form of exercise that almost anyone can do, and 2) its doable for trips that are <1 mile in distance (Handy et al., 2002). Walking is encouraged in studies on older adults and physical activity also because it is acceptable among this population, and is the most natural of activities that doesn’t require any special skills.
(Wong et al., 2003). Because older adults are more likely to be frailer and less agile, their choice of exercise is likely to be lower as well and we cannot expect for them to engage in high-intensity activities as easily, such as jogging. Low to moderate-intensity physical activity is recommended for maintaining health of older adults (Di Pietro, 1996). Furthermore, over half of older adults in the study wanted more opportunities for home activities, and 30% want activities within the community, according to AARP (2004).
Addressing obesity and promoting health is a public priority, and being physically active can be supported through a variety of strategies. One main factor affecting American’s fight to be fit is the environment. The physical environment has recently attracted interest among researchers studying the factors that influence physical activity, yet it is the least understood of the known influences (Humpel, Owen, Leslie, 2002). Despite ecological models that include environmental aspects as one of the determinants of health-related behavior (Figure 2), more research is needed in studying the relationship between environment and physical activity. The evidence to date suggests that the built environment, specifically walkable neighborhoods and features, have been positively associated with physical activity. Thus, the aim of this study is to examine the extent to which walkable neighborhoods influence older adults’ physical activity behavior by using both objective and subjective measures.

**Built environment studies**

Researchers and practitioners of public health, urban designers, and transportation planners have particularly investigated which “correlates” (Bauman, Sallis, Dzewaltowski, Owen, 2002) are associated with physical activity behaviors (Handy, Marlon, Boarnet, Ewing, Killingsworth, 2002; Sallis, Frank, Saelens, Kraft, 2003). Within metropolitan areas, urban planners specifically look to the built environment to understand human activity and behavior, such as travel. The built environment is a multi-faceted term that is characterized by an area’s urban design, land use, and transportation system (Handy et al., 2002). Each of these constituents of the built environment has a significant impact on how humans move within an area.
Figure 2 NHLBI Ecological Model of Diet, Physical Activity, and Obesity

Our environment today is very much a built one as changes in development in the latter half of the past century have resulted in reduced accessibility for pedestrians (Frank, Stone, Bachman, 2000). Accessibility is defined by two aspects: proximity, the linear distance between trip origins and destinations; and connectivity, the level of route directedness associated with travel options (Frank et al., 2000). Due to reduced connectivity of street networks in suburban areas, proximity increased and contributed to vehicle use (Frank et al., 2000). Transportation data has shown that other characteristics of the built environment that discouraged pedestrian accessibility were the scarcity of sidewalks and large building setbacks (Frank et al., 2000).

In one study examining the relationship between community design and physical activity, land-use mix, net residential density, and street connectivity were the urban form measures that were found to be strongly associated with BMI, obesity, and transportation-related activity (Frank, Andresen, and Schmid, 2004). Results indicated that each additional hour spent in a car was linked with a 6% increase in likelihood of becoming obese (Frank et al., 2004). Another study which used urban sprawl as a factor of urban form, found that people living in sprawling counties were likely to walk less, weigh more, and have a higher prevalence for hypertension (Ewing, Schmid, Killingsworth, Zlot, Raudenbush, 2003). These studies show that many aspects of the built environment, from urban sprawl to the way streets are connected, are associated with physical activity, especially walking.

**Walkability and Access**

Walkability is an umbrella term used in research literature on neighborhood environments, and has been positively associated with physical activity in many studies. Environmental audits and surveys may define a walkable neighborhood or city by measuring presence of sidewalks, and having destinations such as parks, walking and biking trails, and facilities and stores, that are within an easy walking
distance from one’s home (Hoehner et al., 2005). In particular, a few studies have found that having key destinations within walking distance from one’s home is a significant environmental influence on physical activity. Hoehner et al. (2005) found that this factor had the strongest correlation of transportation-based activity, confirming similar results from other urban planning studies. In another study, the likelihood of using public open space for physical activity increased with increasing levels of access (Giles-Corti, Broomhall, Knuiman, Collins, Douglas, Ng, Lange, Donovan, 2005).

Local destinations that include post boxes, schools, shops, and transportation facilities have also increased the chances that people will walk (Pikora, et al., 2003). These key destinations add to the walkability of a neighborhood and support both utilitarian and recreational activities, particularly walking or biking for exercise or for means of travel. Recently, another study found associations between neighborhood features and the type of activity one engaged in: transportation- and recreation-based. The study found that “highly-walkable” city respondents were more likely to meet recommendations for physical activity through recreational activity – leisure walking, for example – and also found that lower-income study areas participated in more transportation-based activity (walking and bicycling) (Hoehner, Brennan Ramirez, Elliott, Handy, and Brownson, 2005). Daily commuting is another way people have been found to incorporate utilitarian walking. A study that examined Canadian data found a positive relationship between neighborhood environment scores and walking to work (Craig, Ross, Brownson, Cragg, and Dunn, 2002).

**Neighborhood features (environmental attributes)**

Walking trips are found to be associated with environmental characteristics of the neighborhood (Greenwald and Boarnet, 2002). Researchers have voiced a need for more studies that focus on relationships between individual or household travel and
the built environment (Handy, Marlon, Boarnet, Ewing, and Killingsworth, 2002). In addition to presence of destinations, issues related to personal safety and attractiveness of streetscape were equally found to be most important for walking (Pikora, Giles-Corti, Bull, Jamrozik, Donovan, 2003). Humpel, Owen and Leslie (2002) reviewed 19 studies that examined the environment’s influence on physical activity behavior. The study narrowed the list of barriers, facilitators, and contextual influences to five factors which included accessibility, opportunities for physical activity, weather, safety, and aesthetics. The ease with which one gets to a place that is aesthetically pleasing was commonly found to be a facilitator to physical activity in other neighborhood research studies as well. Greenery and presence of trees and shade along footpaths increased likelihood of people walking locally (Corti, Donovan, Holman, 1996; Wright, MacDougall, Atkinson, Booth, 1996). Giles-Corti and colleagues (2005) found that those with very good access to large, attractive public open space were 50% more likely to engage in high walking levels.

**Older Adults, Environment, and Physical Activity: what we know so far**

Research findings on the relationship between the physical environment and physical activity among the older adult population are scarce, and more research is needed in this area. Older adults recognize how barriers in the built environment can encourage inactivity even when they are aware of the importance of physical activity (Keenan, 2004). The American Association of Retired Persons (AARP) suggests that neighborhood environmental characteristics are likely to matter more for midlife and older adults than for the younger population. This could be because older adults are likely to have more discretionary or leisure time than younger adults. In their study on barriers to physical activity among older adults, Lim et al. (2005) found that only 7% said that lack of time or being too busy was a reason why participants were physically inactive.
Some environmental facilitators that were found to encourage adults 45+ to walk more often were having more places to go within walking distance, smooth sidewalks and crosswalks, good lighting, and no sidewalk obstacles (Keenan, 2004). Booth et al. (2000) found accessibility of local facilities to be positively associated with older adults being physically active in their leisure time. King, Brach, Belle, Killingsworth, Fenton, and Kriska (2003) found that the ability to make utilitarian walking trips from home and the perception of having favorable neighborhood surrounds for walking were associated with increased physical activity levels among older women. Walking levels increased as the number of walkable destinations from one’s home increased, specifically within walking distance of a park, biking or walking trail, or stores (King et al., 2003). Data have indicated that older adults prefer living near walking and biking trails as the top amenity people look for when looking for a new home (Ahrentzen, 2004).

Environmental barriers, on the other hand, discourage one from engaging in physical activity. Imagine the task of an older adult crossing a street: because one is likely to be less mobile, he/she can become frustrated when the “walk” light turns to the blinking hand when he/she has only crossed halfway. The signal could be telling the older person that he/she needs to walk faster. Other environmental barriers found to challenge older adults are lack of curb ramps and benches, absent or poorly maintained sidewalks, and excessive traffic speed (Sallis, 2003). However, one study found that perceived neighborhood safety had no independent association with physical activity in older adults, (Lim et al., 2005). One study done in Tokyo’s metropolitan area found associations between the quality of the physical environments near a residence and the longevity of senior citizens (Takano, Nakamura, and Watanabe, 2002). The physical characteristics positively associated with longevity were convenience and walkability of green spaces and length of residence. According
to the results of Takano and colleagues (2002), five year survival of subjects was greater for those having residential spaces to take a stroll or parks and tree-lined streets near their residence.

This review has supported the argument that many Americans live in a social and physical environment that encourages a lifestyle of minimal physical activity. This has contributed to obesity among nearly all ages, ethnicities, and incomes, but particularly low-income minority women. Of particular interest are older adults, who constitute the least physically active and most vulnerable, but least studied, population. Solid scientific research on the health effects of physical activity has indicated the importance of an active lifestyle on the quality of life and longevity of older Americans. Along with addressing other social, psychological, and demographic barriers, developing research on the built environment has found that physically active behavior in older adults can be promoted through environmental characteristics that facilitate walking and other modes of active transport, are attractive, and safe.
CHAPTER 1-E. GOALS AND HYPOTHESES

Goals

In the field of physical activity research, two at-risk groups are underrepresented in studies thus far: older adults in general and minorities in particular (Eyler, 2002; Evenson et al., 2002). This study’s basic purpose is to examine environmental influences on physical activity patterns among older urban residents, and to observe the relationship of physical activity in older minority and non-minority adults – specifically among Asians.

This study aims to:

1. Analyze the role of walkable neighborhoods for older adults.
2. Understand which factors of the physical environment are most important for encouraging older adults to walk.
3. Verify other personal factors affecting physical activity, including ethnicity, the affects of acculturation, age, SES, and BMI.

Hypotheses

The hypotheses for this study relate explicitly to environmental factors and suggest that objective walkability, perceived neighborhood environment, walking purpose, English language comfort level, and perceived social support affect physical activity levels in older adults.

1. Downtown sites (in both Ithaca, NY and San Diego, CA) will measure higher in objective walkability (as measured by CDC Walkability Audit Tool) than rural (Ithaca) or suburban (San Diego) areas.
2. Independent older adults who live in a more walkable area (as measured by CDC Walkability Audit Tool) will have higher physical activity levels than those who live in less walkable areas.
3. Independent older adults who live in a more walkable area (as measured by CDC Walkability Audit Tool) will have higher physical activity levels than those who live in less walkable areas.

4. If Hypotheses 1 and 2 are true, then independent older adults living in downtown areas will have higher physical activity levels than those living in suburban or rural areas.

5. Older adults who perceive their neighborhood environment to be higher in walkability (as measured by Neighborhood Environment Walkability Scale (Saelens, Sallis, Black, Chen, 2003) will have higher physical activity levels than those who perceive it to be less walkable.¹

6. Independent older adults living in downtown areas will walk more for utilitarian purposes than recreational, with utilitarian form being those activities worked into one’s daily routines (Arhentzen 2004).

7. Older adult residents who have more perceived social support will engage in more physical activity.

¹ The neighborhood perception measure, NEWS, was administered only in Ithaca and thus this hypothesis was analyzed using Ithaca data.
CHAPTER 2. METHOD

Design

This cross-sectional examination of the effects of the physical environment on physical activity of older adults studied data of those living independently in senior apartments within 2 main sites: the San Diego, CA and Ithaca, NY areas. The study accomplished the collection of physical activity data of an older adult, ethnically diverse sample.

Independent Variables

Physical environment: Data were obtained through use of the Walkability Audit Tool, an objective measure from the Centers for Disease Control (2004) which was originally developed to measure the walkability of a worksite environment. The survey involves the PI visiting the identified segments of the site and auditing walkability. Using a 1 to 5 scale, the following features were rated by 9 items in the instrument and scored by High, Medium, and Low importance:

- Pedestrian Facilities - High
- Pedestrian Conflicts - High
- Crosswalks - High
- Maintenance - Medium
- Path Size - Medium
- Buffer - Medium
- Universal Accessibility – Medium
- Aesthetics - Medium
- Shade – Low

For example, Pedestrian Conflicts stated, “potential for conflict with motor vehicle traffic due to driveway and loading dock crossings, speed and volume of traffic, large intersections, low pedestrian visibility.” The descriptions were: 1 – High conflict potential and 5 – Low conflict potential. The scores for each site ranged from 0-100.

Individual demographics and health: Descriptive/ variables that were measured are health factors, including current smoking behavior, as well as demographic
information: gender, age, BMI, length of time spent in residence, SES, and ethnicity (including language and comfort with speaking English). Other variables include walking difficulty and incontinence.

**Dependent Variables**

*Physical activity (“PA”) level:* The Accusplit Eagle 170 Deluxe Fitness Meter ([www.accusplit.com](http://www.accusplit.com)) pedometer with pedometer leash was used. This small black device counts steps walked through detection of vertical oscillations of the leg and digitally indicates the number on the screen. The total number of steps in a week was recorded in the travel log. The travel log was another measurement of PA, which had spaces to record trips from one address to another, purpose of trip, method of travel, and approximate travel distance, along with a space for end-of-the-day step meter reading. The CHAMPS Activities Questionnaire for Older Adults (Stewart, 1998) measured caloric expenditure through a series of activities participants may have done in the past 4 weeks in a typical week.

*Neighborhood perceptions:* A modified version of the NEWS (Saelens et al., 2003) was used to assess neighborhood environmental perceptions for each respondent in only the Ithaca area. The original survey included sections on types of residences, the street/walking environment, and neighborhood satisfaction, and a few questions on jobs and schools in the neighborhood facilities and businesses section. These sections and items were omitted for the purpose of time and relevance.

*Social Aspects:* A modified version of “Social Aspects of Living” (Kweon, Sullivan, Wiley, 1998) was used to measure the affects of the residence’s social atmosphere on the individual. Minor changes in wording were required to be relevant to the residence.

*Weather:* Average highs, lows, and precipitation levels were recorded using data from an internet weather sites for the sites of Ithaca ([www.weather.com](http://www.weather.com)) and San Diego
(http://www.wrh.noaa.gov) for the days in which participants walked with the pedometers.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measurements</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent Variable: Physical Activity Level</td>
<td>Accusplit Eagle 170 Deluxe Fitness Meter Pedometer</td>
<td>Measures number of steps, worn for 7 consecutive days</td>
</tr>
<tr>
<td></td>
<td>Travel Log</td>
<td>A record of the day’s travel that asks the participant to record the start and arrival times and purpose, method, and length of travel for 7 consecutive days. The log records total number of steps in a week</td>
</tr>
</tbody>
</table>
| | Community Healthy Activities Model Program for Seniors (CHAMPS) | A self-report questionnaire that measures what and how long the participant did an activity in a typical week during the past 4 weeks. It includes a range of activities, including:  
- Playing cards, golf, bingo  
- Going to church, group meetings, doing volunteer work  
- Gardening, reading, and walking |
| Determinant Variable | Neighborhood Environment Walkability Scale (NEWS) | To assess the participant’s perceptions on one’s neighborhood environment:  
- Land use mix – diversity  
- Land use mix – access  
- Walking/cycling facilities  
- Aesthetics  
- Pedestrian/Traffic safety  
- Crime safety |
| Determinant Variable | Social Aspects of Living at Residence | To measure the participant’s perception of the residence’s social atmosphere |
| Determinant Variable | Average weather temperature, precipitation | To measure the average high, low, and precipitation levels for the week participants took part in pedometer/travel log section of study |
| Independent Variable | CDC Walkability Audit Tool | A tool that helps one assess the walkability of an area in terms of factors related to safety, aesthetics, and recreational potential, with safety being the most important. |

**Setting**

The setting is San Diego, California’s urban neighborhood and downtown Ithaca, New York’s independent senior apartments, as well as two sites approximately 12 miles away from both sites: Chula Vista, California and Trumansburg, New York. The former site was chosen for their agreement to participate and the high percentage of
non-white residents, mostly of Korean and Japanese decent. The latter site was chosen also for their participation for higher recruitment purposes in Ithaca. The Principal Investigator (PI) aimed to have at least 30 participants total from both locations.

**Downtown San Diego, CA**

The downtown San Diego location is less than 2 miles from the coastline and within a compact grid east of the San Diego Bay, approximately 3 miles southeast of San Diego’s airport. The main street is Broadway, which runs in the middle of the town, and the apartment sites are several blocks away from this street (Figure 3).

**Suburban San Diego: Chula Vista, CA**

The independent senior apartment in Chula Vista, CA is an inland area located 12 miles southeast of downtown San Diego, the city accessible by a trolley line. It is located within a grid system less compact than San Diego, and thus is in more of a suburban area (Figure 4).

**Downtown Ithaca, NY**

The 2 residences that participated are low-income housing located in or near the downtown Ithaca area, and close to Cornell University (Figure 5).

**Rural Ithaca: Trumansburg, NY**

The final residence that was recruited is located in a small rural town 12 miles northwest of downtown Ithaca in the village of Trumansburg, off of the New York State Route 96 (Figure 6).

**Procedure**

**Recruitment**

Because the San Diego area was for pilot study purposes, a much simpler approach was used for recruitment at first. After agreement with the building manager, a sign up sheet to participate in the study was put on bulletin boards in residences’ lobbies, as well as information about the study on half-sheets of paper placed in the
Figure 3 Downtown San Diego residence

Figure 4 Suburban San Diego residence
Figure 5 Downtown Ithaca residence

Figure 6 Rural Ithaca residence
lobby. In the Chula Vista apartment, a resident leader helped in the recruitment process by personally informing the residents, asking for their participation, and later helping to administer the questionnaires.

After experiencing the recruitment process in San Diego and Chula Vista, California, the method was improved in Ithaca and Trumansburg. With the cooperation of building managers, colorful flyers with images, which asked the question, “Curious about how much you walk?”, were posted on community bulletin boards in the lobby and in one case, attached to the monthly newsletter as well. The flyers indicated a date and time of the principal investigator’s visit to the residence to further explain the study, in addition to compensation and the chance to enter a raffle drawing.

Protocol

1. Within each facility, an informal session was held by the PI on the basics of the study and what will be asked of residents who wish to participate. The PI emphasized that one does not need to be active to begin with in order to participate to create a more representative sample of the older adult population.

2. The residents who indicated interest in participating were read the consent form, assessed for eligibility, signed up for interview dates and times, administered survey instruments, and trained in the use of the pedometers.

3. Participants were given a pedometer to measure their actual activity level for 7 days. They were instructed by the PI who made sure each person can open the cover by themselves and then went through a step study basics form. The instructions given were to attach the pedometer firmly to their pants waist or belt, positioned above the right or left hip and in line with their knee, and to wear it for 7 consecutive days. They were asked to wear it over or under their
clothing during waking hours when not engaging in water-related activities such as swimming or showering. For the Ithaca/Trumansburg participants, a sign to hang on one’s door knob was also given to remind them to put on their pedometers each morning.

4. In addition to the pedometer measure, participants were asked to record their activities on foot in an activity log that was provided.

5. All parts of the interviews were conducted by the PI, excluding some within the Chula Vista residence, on a date and time agreed with the participant.

6. When all measures are completed, participants will mail the pedometer and activity log in a stamped addressed envelope provided, or the PI will pick it up personally, and will be mailed $5 compensation. Each participant in the Ithaca, NY area will be entered in a raffle within their facility to win $25 gift certificates to a local restaurant.

**Statistical Analysis**

Data analyses were conducted using SPSS Version 13.0 for Windows (SPSS Institute Inc., Chicago, IL, 2005). Relationships between dependent and determinant variables and physical activity were analyzed using t-test or analysis of variance (ANOVA) for categorical variables and Pearson correlation coefficient for continuous variables. Analyses related to each of the three measurements of the dependent variable, physical activity, were conducted separately. Mean step count per week was derived using the following equation: 

\[
\text{Mean step count per week} = \left( \frac{\sum \text{total step count}}{\# \text{days recorded}} \right) \times 7
\]

Because the travel log data had no set method for analysis, the PI chose to analyze percentage of trips on foot, percentage of walking trips for destination purposes, and percentage of walking trips for leisure/enjoyment purposes. Continuous variables were centered about the mean. Percentage of trips on foot was derived using the equation: 

\[
\text{Percentage of trips on foot} = \left( \frac{\# \text{trips on foot}}{\text{total} \# \text{walking and motor-based trips}} \right) \times 100
\]
Weather was considered a continuous variable by deriving per participant the average high and low of the 7 days each participant walked, as well as the percentage of days it precipitated of the 7 days. Only those continuous variables deemed significant at the 0.05 and 0.01 level were given the N and p-values (Table 7). Reliability between objective (CDC Walkability Audit) and perceived environment (NEWS) measures was conducted by using t-test and comparing NEWS subscores to the overall CDC score at the 0.1, 0.5, and 0.01 levels (Table 6).

Subjects

Participants were recruited in the downtown San Diego and suburban Chula Vista site in January 2005 and in the downtown Ithaca and rural Trumansburg site between April and June 2005. Within each site, several facilities were chosen at which participants were recruited through their residences by the PI. The selection of each facility was dependent on the approval of the building manager or service coordinator. The study recruited 24 and 25 participants per site to total 49 Caucasian, African-American, and Asian-American older adults ranging from aged 60 to 92 years. Older adults were excluded if they did not meet the requirements for eligibility, which were: a) being 60 years of age or older, b) ability to complete written surveys in English (or Korean), and c) not having a disability that does not permit walking, i.e. wheel-chair bound. Translated versions of the questionnaires in Korean were used for those who could only communicate in Korean.

Of 49 participants, 35 (or 71%) completed the pedometer section of the study, and 25 (or 51%) completed the pedometer with the travel log section. Because the data collection in San Diego was done before Ithaca, various items are missing for both Downtown and Suburban areas since they were added on to the study later. These include the demographic and health-related variables on income range, past smoking
behavior, and the dependent variables NEWS and Social Aspects of living at their residence.

Table 1 shows the demographics within the four sites in terms of age, gender, ethnicity, native language, English comfort level, income range, and length of residency. The overall mean age is 77.4 years, although residents in Rural Ithaca have the lowest mean age at 72. Women were the majority of the participants in each site averaging 77.6% overall, and the Rural Ithaca site were all female participants. A difference in ethnicity and native language was apparent between San Diego and Ithaca sites. Downtown San Diego had the most mix with Caucasians, African-Americans, and Asians, with almost half of the participants having spoken Korean. Suburban San Diego had almost all Asian participants and no one had English as their native language, but spoke mostly Korean or Japanese. Downtown and Rural Ithaca sites were both predominantly Caucasian and overall, no one in this sample had trouble completing the questionnaires due to their native language. English comfort level for Downtown San Diego was split half and half between those who were comfortable and those who were somewhat uncomfortable to uncomfortable in the situation of speaking to someone who only knows English. One hundred percent of Ithaca residents, on the other hand, were comfortable speaking English.

Table 1 also shows the sample’s health-related variables in terms of BMI mean and categories, self-reported health level, incontinence by asking if participants have trouble with their bladder, walking difficulty, and past smoking behavior. BMI mean for each residence ranged from 25.1 in suburban San Diego to 32.1 in rural Ithaca. No one was reported to be in the underweight category, and most participants overall fell in the normal or overweight categories. Self-reported health variable had more than half of participants reporting their health as good or very good, and the majority of the rest reporting their health as fair or poor. Most participants overall (75.5%) said they
did not have any trouble with their bladder, but “walking difficulty” had varied responses. Most said they did not have difficulty walking in Downtown and Suburban San Diego (about 77%), while most in Downtown and Rural Ithaca sites (about 70%) said they did. Questions on smoking behavior were asked only in Ithaca sites, and out of the 66.7% who had smoked in the past, no one smokes currently.
Table 1 Sample Demographic Variables

<table>
<thead>
<tr>
<th></th>
<th>Overall n=49</th>
<th>San Diego Downtown n=11</th>
<th>Suburban n=14</th>
<th>Ithaca Downtown n=18</th>
<th>Rural n=6</th>
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<td><strong>Gender, %</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
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<td>63.6</td>
<td>71.4</td>
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</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
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<td>Korean</td>
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<td>Comfortable</td>
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<td><strong>Income range, %</strong></td>
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<td><strong>Self-reported health, %</strong></td>
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<td>Poor to Fair</td>
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<td>24.5</td>
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<tr>
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<td>75.5</td>
<td>81.8</td>
<td>92.9</td>
<td>55.6</td>
<td>83.3</td>
</tr>
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<td><strong>Difficulty walking, %, Yes No</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44.7</td>
<td>18.2</td>
<td>25.0</td>
<td>61.1</td>
<td>83.3</td>
</tr>
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<td>No</td>
<td>55.3</td>
<td>81.8</td>
<td>75.0</td>
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</tr>
<tr>
<td><strong>Ever smoked, %, Yes No</strong></td>
<td></td>
<td></td>
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<tr>
<td>Yes</td>
<td>66.7</td>
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<td>No data</td>
<td>61.1</td>
<td>83.3</td>
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<tr>
<td>No</td>
<td>33.3</td>
<td></td>
<td>No data</td>
<td>38.9</td>
<td>16.7</td>
</tr>
<tr>
<td><strong>Mean Age (SD)</strong></td>
<td>77.43 (7.80)</td>
<td>78.73 (7.14)</td>
<td>78.43 (4.91)</td>
<td>77.44 (9.4)</td>
<td>72.67 (9.2)</td>
</tr>
<tr>
<td><strong>Length of residency, Mean years (SD)</strong></td>
<td></td>
<td>10.33 (9.63)</td>
<td>15.73 (14.12)</td>
<td>9.38 (7.18)</td>
<td>8.87 (8.13)</td>
</tr>
<tr>
<td><strong>Mean BMI (SD)</strong></td>
<td>27.19 (5.92)</td>
<td>25.48 (4.10)</td>
<td>25.13 (3.76)</td>
<td>28.19 (7.2)</td>
<td>32.12 (6.3)</td>
</tr>
</tbody>
</table>

*a n is the largest possible sample size and are smaller for some physical activity measures than others*
CHAPTER 3. RESULTS

We will present the findings in order of the main hypotheses related to the relationship between neighborhood walkability and physical activity, followed by perception of neighborhood, analysis of subjects’ walking purposes, and finally of the relationship between demographic factors and physical activity among this population of older adults.

Objective Walkability and Physical Activity

_Hypothesis 1._ Downtown sites (in both Ithaca, NY and San Diego, CA) will be rated higher in objective walkability (as measured by CDC Walkability Audit Tool) than rural (Ithaca) or suburban (San Diego) areas.

Consistent with the hypothesis, downtown sites in both San Diego and Ithaca scored higher in objective walkability, 82.0 and 82.7 respectively, than the corresponding suburban (San Diego) and rural (Ithaca) sites, 64.0 and 70.0, respectively (Table 2). Across all of the walkability features, Downtown San Diego scored higher than or equal to Suburban San Diego (Table 2). Among the nine walkability features, Downtown San Diego scored higher than suburban San Diego on 7 items and equal on 2 items. Similarly, Downtown Ithaca scored higher than Rural Ithaca (on 5 items) or equal (on 2 items) on walkability features, with the exception of Pedestrian Conflicts and Shade. Because this instrument is a site-based measure that was completed by the on-site rater, a statistical comparison of means is not possible; we can only state that the ratings were in the predicted direction. The unit of analysis is the sites, n=4.

_Hypothesis 2._ Independent older adults who live in a more walkable area (as measured by CDC Walkability Audit Tool) will have higher physical activity levels than those who do not.
Hypothesis 2 was evaluated using 3 types of physical activity data: 1) step counts per week, measured by pedometers, 2) calorie expenditure per week, measured by CHAMPS questionnaire, and 3) percentage of trips on foot and purpose of trips, as reported in the travel log. Table 3 summarizes t-test results of physical activity differences between sites.

Downtown Ithaca and Downtown San Diego were objectively rated by the CDC Audit instrument as more walkable sites than both the Suburban San Diego and Rural Ithaca sites, and thus the downtown residents are predicted to have higher physical activity levels. Because their CDC scores were similar, the San Diego and Ithaca data sites were combined to allow an overall downtown versus suburban/rural comparison (Table 3).

Across all measurements of physical activity, there were no statistically significant differences between residents in Downtown and Suburban-Rural sites (Table 3). Downtown residents scored higher in calorie expenditure (2348 vs. 1963, t(45)=0.81, p=0.42) and percentage of trips on foot (46.4% vs. 47.9%, t(24)=0.09, p=0.931) but lower in mean step count (23,486 vs. 29,037, t(33)=0.93, p=0.36), (Table 3).
In terms of the first measure of physical activity, **step count**, Downtown sites had a mean of 23,486 steps, and Suburban-Rural sites had a mean of 29,037 steps, \( t(33)=0.93, p=0.36 \). In this measure, we find that residents of Suburban-Rural sites walked more steps than Downtown sites although the difference was not statistically significant.

The second measure of physical activity, **calorie expenditure** per week, showed Downtown sites with a higher mean calorie expenditure per week (2348) than Suburban-Rural sites (1963), \( t(45)=0.81, p=0.42 \). Again, we do not find a statistically significant difference, but here the trend is in the predicted direction with downtown residents expending more calories per week.

The third measure of physical activity utilized the travel log to determine the weekly **percentage of trips on foot** and purpose of the trips: whether they are for traveling to a destination or for leisure and enjoyment. Combined data for Downtown sites and Suburban-Rural sites in Table 3 found no difference of means in percentage of trips made on foot in this analysis: 46.4% for Downtown sites, and 47.9% for Suburban-Rural sites (\( t(24)=0.09, p=0.931 \)). The results for combined data can be seen as more reliable because of the larger sample size for both Downtown sites (n=29) and Suburban-Rural sites (n=20) (Table 3).

However within San Diego, there was a significant difference between the downtown and suburban residents’ travel log data, with suburban residents reporting higher percentage of trips on foot, 90% vs. 34.3% (\( t(5) = 2.72, p=0.04 \)). This was inconsistent with the hypothesis because it was predicted that downtown sites would have higher percentage of trips on foot (Table 3). It was also concluded that Suburban San Diego residents had a higher percentage of walks for leisure/enjoyment than Downtown San Diego residents: 86.4% vs. 32.3% (\( t(5)=2.19, p=.08 \)). This was consistent with the hypothesis because results support the prediction that suburban
residents would walk more for leisure and enjoyment purposes than downtown residents. Nevertheless, because of the modest sample size (n=6), the results from San Diego are not clear nor heavily weighed upon.

Perceived Environment

**Hypothesis 3.** Older adults who perceive their neighborhood environment to be higher in walkability, as measured by Neighborhood Environmental Walkability Scale (NEWS), will have higher physical activity levels than those who perceive it to be less walkable.¹

Table 3. Independent Sample T-Tests – Physical Activity Measurements

<table>
<thead>
<tr>
<th>Physical Activity (mean)</th>
<th>San Diego Downtown n=11 a</th>
<th>Suburban n=14 a</th>
<th>Ithaca Downtown n=18 a</th>
<th>Rural n=6 a</th>
<th>San Diego and Ithaca Downtown combined n=29 a</th>
<th>Suburban-Rural combined n=20 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step count/week</td>
<td>24654</td>
<td>36065</td>
<td>22986</td>
<td>18494</td>
<td>23486</td>
<td>29037</td>
</tr>
<tr>
<td>Calorie expenditure/week</td>
<td>2388</td>
<td>2076</td>
<td>2328</td>
<td>1697</td>
<td>2348</td>
<td>1963</td>
</tr>
<tr>
<td>Percentage of trips on foot</td>
<td>34.3</td>
<td>* 90.0</td>
<td>50.7</td>
<td>31.0</td>
<td>46.40</td>
<td>47.9</td>
</tr>
</tbody>
</table>

a n is the largest possible sample size and are smaller for some physical activity measures than others
*p< .05

Table 4 presents the NEWS score comparison between Ithaca sites. Data indicate that there was a statistically significant difference in the mean NEWS scores between Downtown and Rural Ithaca in 3 aspects. Compared to Rural Ithaca residents, Downtown Ithaca residents perceived their neighborhood to have more diversity of land

---

1 NEWS and Social Aspects measures were administered and analyzed only in Ithaca.
use: mean 3.12 vs. 3.03 (t(22)=1.73, p=.003); more accessible land use: mean 3.36 vs. 2.20 (t(22)=3.21, p=.099); and have more walking/cycling facilities: mean 3.12 vs. 3.25, t(22)=.65, p=.004) (Table 4). Among the remaining NEWS measurements, there were no statistically significant differences. The trend, however, was that Downtown Ithaca was perceived as higher in Aesthetics: 3.38 vs. 2.69 (t(22)=1.43, p=.520), and Crime safety: 3.02 vs. 2.01 (t(22)=3.33, p=.160), but lower in Pedestrian/traffic safety: 2.42 vs. 3.36 (t(22)=1.64, p=.168), (Table 4).

Table 4. Social Aspects and NEWS Variables

<table>
<thead>
<tr>
<th>Social aspects of living in residence</th>
<th>Ithaca Downtown mean (SD)</th>
<th>Ithaca Suburban mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=18</td>
<td>n=6</td>
<td></td>
</tr>
<tr>
<td>Diversity - land use mix</td>
<td>3.12 (.78)</td>
<td>* 3.03 (.42)</td>
</tr>
<tr>
<td>Access – land use mix</td>
<td>3.36 (.40)</td>
<td>+ 2.20 (.13)</td>
</tr>
<tr>
<td>Walking/cycling facilities</td>
<td>3.12 (.69)</td>
<td>* 3.25 (.34)</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>3.38 (.45)</td>
<td>2.69 (.32)</td>
</tr>
<tr>
<td>Pedestrian/traffic safety</td>
<td>2.42 (.43)</td>
<td>3.36 (.37)</td>
</tr>
<tr>
<td>Crime safety</td>
<td>3.02 (.47)</td>
<td>2.01 (.36)</td>
</tr>
</tbody>
</table>

1 The neighborhood perception measure, NEWS, and Social Aspects measure were administered only in Ithaca.
+ p<.10
* p<.05

Because NEWS is the primary independent variable, we expect the NEWS subscale variables to be different between sites. Table 5 indicates which of the six NEWS variables were significant predictors of physical activity, as measured by step count, calories expended per week, and percentage of trips taken on foot. Results presented in Table 5 support Hypothesis 3 in that physical activity can be explained by perceived environmental aspects. The only significant NEWS predictor of step count per week was the NEWS
rating “Land use mix – diversity” (F(1,18)=6.140, p=.023); significant variables of calorie expenditure per week were “Walking/cycling facilities” and “Aesthetics” (F(2,21)=7.286, p=.004); and of Percent trips on foot they were “Crime safety” and “Aesthetics” as well (F(2,16)=3.445, p=.057) (Table 5).

Table 5. Linear Regression Analysis -The effects of perceived neighborhood environment on physical activity

<table>
<thead>
<tr>
<th>Physical Activity (mean)</th>
<th>Predictors</th>
<th>Sig.</th>
<th>Standardized Beta</th>
<th>R-sq.</th>
<th>F</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step count/week</td>
<td>Land Use Mix – Diversity</td>
<td>.023</td>
<td>.50</td>
<td>.254</td>
<td>6.14</td>
<td>1, 18</td>
<td>.023 *</td>
</tr>
<tr>
<td>Calorie expenditure/week</td>
<td>Walking/cycling facilities</td>
<td>.010</td>
<td>.47</td>
<td>.353</td>
<td>7.29</td>
<td>2, 21</td>
<td>.004 **</td>
</tr>
<tr>
<td>Percentage of trips on foot</td>
<td>Crime safety</td>
<td>.067</td>
<td>-.42</td>
<td>.214</td>
<td>3.45</td>
<td>2, 16</td>
<td>.057 +</td>
</tr>
<tr>
<td></td>
<td>Aesthetics</td>
<td>.049</td>
<td>.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ p<.10
* p<.05
** p<.01

Walking Purpose

Travel log data were examined after considering what the purpose of walking was for this sample of older adults, and whether the purposes differed by sites. Table 6 shows the travel log data analyzed in two ways: Walking to a Destination and Walking for Leisure/Enjoyment.

Hypothesis 4. Independent older adults living in downtown areas will walk more for destination purposes than for leisure/enjoyment.

Although results were in the predicted direction, none of the differences between Downtown sites and Suburban-Rural sites were found to be significant (Table 6). However, a comparison of trip purposes revealed that differences in Destination
Walking were marginally significant, with higher destination walking in Downtown sites (50.7%) than in Suburban-Rural sites (24.3%), t(24)=1.54, p=.14 (Table 6). People living in downtown sites walked less for leisure/enjoyment purposes (33.5%) than did residents in combined Suburban-Rural sites (47.1%), t(24)=.80, p=.43 (Table 6). Destination walking trips were coded as independent from leisure walking trips.

Table 6 Independent Sample T-Tests – Walking Purpose

<table>
<thead>
<tr>
<th>Walking Purpose (mean %)</th>
<th>San Diego</th>
<th></th>
<th>Ithaca</th>
<th></th>
<th>San Diego and Ithaca</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Downtown</td>
<td>Suburban</td>
<td>Downtown</td>
<td>Rural</td>
<td>Downtown combined</td>
</tr>
<tr>
<td></td>
<td>n=11 a</td>
<td>n=14 a</td>
<td>n=18 a</td>
<td>n=6 a</td>
<td>n=29 a</td>
</tr>
<tr>
<td>Walking to a destination</td>
<td>47.7</td>
<td>13.6</td>
<td>51.8</td>
<td>28.6</td>
<td>50.7</td>
</tr>
<tr>
<td>Walking for leisure/enjoyment</td>
<td>32.3 + 86.4</td>
<td>33.9 31.4</td>
<td>33.5 47.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a n is the largest possible sample size and are smaller for some physical activity measures than others
+p<.10
*p<.05

**Personal Factors**

A variety of personal factors are predicted to be correlates of physical activity levels, primarily BMI, self-reported health levels, incontinence, difficulty with walking, age, and length of residence. In order to study the comparability between groups of the combined sites (Downtown and Suburban-Rural), chi-square tests were conducted for these personal factors (Table 7).

**Hypothesis 5.** Older adult residents who have either “Normal” BMI scores (18.5-24.9) or “Good” to “Excellent” self-reported health levels will engage in more physical activity than those with BMI scores 25+ or “Fair” to “Poor” self-reported health levels.

Regardless of residence, BMI had a strong negative correlation with step count
per week. BMI scores were very similar between Downtown sites and Suburban-Rural sites (27.16 and 27.23, respectively, Table 8). BMI and step count per week were found to be was highly negatively correlated ($r=-.52$, $p=.00$, Table 8). The same pattern was found between BMI and percentage of trips on foot ($r=-.44$, $p=.03$) but not for calorie expenditure (Table 8).

Table 7. Demographic Variables Chi-Square Analysis

<table>
<thead>
<tr>
<th></th>
<th>San Diego &amp; Ithaca</th>
<th>Downtown n=29*</th>
<th>Suburban-Rural n=20*</th>
<th>Chi-square (df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>24.1</td>
<td>20.0</td>
<td></td>
<td>.12(1)</td>
<td>.73</td>
</tr>
<tr>
<td>Female</td>
<td>75.9</td>
<td>80.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ethnicity, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caucasian</td>
<td>65.5</td>
<td>30.0</td>
<td></td>
<td>10.37(3)</td>
<td>.02 **</td>
</tr>
<tr>
<td>Asian</td>
<td>6.9</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>African-American</td>
<td>20.7</td>
<td>65.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>6.9</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Native Language, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>English</td>
<td>75.9</td>
<td>30.0</td>
<td></td>
<td>15.25(4)</td>
<td>.00 **</td>
</tr>
<tr>
<td>Korean</td>
<td>17.2</td>
<td>55.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japanese</td>
<td>0</td>
<td>15.0</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Other</td>
<td>6.8</td>
<td>0</td>
<td></td>
<td></td>
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<tr>
<td><strong>English comfort level, %</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Comfortable</td>
<td>82.8</td>
<td>40.0</td>
<td></td>
<td>10.88(4)</td>
<td>.03 *</td>
</tr>
<tr>
<td>Somewhat comfortable</td>
<td>0</td>
<td>10.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>0</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Somewhat uncomfortable</td>
<td>6.9</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncomfortable</td>
<td>10.3</td>
<td>25.0</td>
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<td></td>
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<td><strong>Income range, %</strong></td>
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<td>Below $15,000</td>
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<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>$15,000-$24,999</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td>$25,000-$34,999</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
<td>No data</td>
</tr>
<tr>
<td><strong>Self-reported health, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor to Fair</td>
<td>42.9</td>
<td>35.3</td>
<td></td>
<td>.25 (1)</td>
<td>.62</td>
</tr>
<tr>
<td>Good to Excellent</td>
<td>57.1</td>
<td>64.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Incontinence, %, Yes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>34.5</td>
<td>10.0</td>
<td></td>
<td>3.84 (1)</td>
<td>.05 +</td>
</tr>
<tr>
<td>65.5</td>
<td>90.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Difficulty walking, %,</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>44.8</td>
<td>44.4</td>
<td></td>
<td>.001 (1)</td>
<td>.98</td>
</tr>
<tr>
<td>No</td>
<td>55.2</td>
<td>55.6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Have ever smoked, %</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>No data</td>
<td>No data</td>
<td>1.00 (1)</td>
<td>.32</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>No data</td>
<td>No data</td>
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</table>
Table 8. Significant Correlations between Physical Activity and Dependent Variables

<table>
<thead>
<tr>
<th>Dependent Variables</th>
<th>Calorie expenditure/week n=48 a</th>
<th>Step count/week n=35</th>
<th>Travel Log Data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r p</td>
<td>r p</td>
<td>r p r p r p</td>
</tr>
<tr>
<td>Age</td>
<td>-.16 .25</td>
<td>-.33 .06+</td>
<td>.12 .55 .08 .71</td>
</tr>
<tr>
<td>BMI</td>
<td>-.08 .59</td>
<td>-.52 .00**</td>
<td>-.44 .03* -.43 .03*</td>
</tr>
<tr>
<td>Weather</td>
<td>-15 .39</td>
<td>-.32 .06*</td>
<td>.15 .48 -.06 .98</td>
</tr>
<tr>
<td>Percentage of precipitation days/7</td>
<td>-.15 .39</td>
<td>-.32 .06*</td>
<td>.15 .48 -.06 .98</td>
</tr>
</tbody>
</table>

a n is the largest possible sample size and are smaller for some physical activity measures than others
+ p<.10
* p<.05
** p<.01

T-test results in Table 9 show Self-reported health as a significant demographic variable in determining step count per week, as well as Incontinence and Difficulty walking. Those reporting Good to Excellent health (t(31)=2.68, p=.01), “No” to Incontinence (t(33)=1.68, p=.10), and “No” to Difficulty walking (t(32)=-2.71, p=.01) had significantly higher mean step count than those who reported Fair to Poor health, “Yes” to Incontinence, and “Yes” to Difficulty walking (Table 9). Although Self-reported health only significantly predicted Step count per week, results were in the predicted direction for predicting the other two physical activity measurements.
Individuals with Good to Excellent Health also had higher calorie expenditure than those who rated themselves as having Poor to Fair Health (2366.4 vs. 1625.8, t(41)=-1.54, p=.13), and higher percentage of trips on foot (52% vs. 33%, t(22)=-1.22, p=.26) (Table 9).

Table 9. Demographic Variables and Physical Activity T-test

<table>
<thead>
<tr>
<th></th>
<th>Mean calorie expenditure/week (n)</th>
<th>Mean step count/week (n)</th>
<th>Mean percentage of trips on foot (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>21540.3 (7)</td>
<td>0.54 (5)</td>
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<td>26946.3 (28)</td>
<td>0.48 (20)</td>
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<td>30677.3 (12)</td>
<td>0.47 (5)</td>
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<tr>
<td>All other ethnicities</td>
<td>2345.1 (29)</td>
<td>23354.4 (23)</td>
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<td>22713.5 (21)</td>
<td>0.46 (19)</td>
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<td>All other languages</td>
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<tr>
<td>Less than comfortable</td>
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<td>18810.9 (13)</td>
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<td>$15,000 and above</td>
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<td>Poor to Fair</td>
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<td>2136.3 (25)</td>
<td>32847.7 (19)</td>
<td>0.51 (12)</td>
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<tr>
<td><strong>Have ever smoked</strong></td>
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<td></td>
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<td>Yes</td>
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<tr>
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+ p<.10
* p<.05
** p<.01
*Hypothesis 6.* Older adult residents who have more perceived social support will engage in more physical activity.

Perceived social support was measured in Ithaca only. Results indicated no significant correlation between the social aspects variable and physical activity level in Ithaca.
DISCUSSION

Summary

The findings of this study suggest a more complex connection between environment and physical activity among older adults than originally hypothesized. The similarity in physical activity level between older adult residents of downtown, objectively more walkable sites and those of suburban/rural, objectively less walkable sites may be explained by factors other than objective environmental characteristics. One of the few statistically significant findings indicated the importance of perceived walkability among older adults as a predictor of physical activity. Perceiving more destinations within walking distance from one’s home, aesthetics, availability of pedestrian facilities, and low neighborhood crime were perceived environmental factors that were significant in determining physical activity levels. Other significant predictors of physical activity that are consistent with past research were personal variables related to good physical functioning, such as normal BMI, reporting “Good” to “Excellent” health, and having no incontinence or walking problems.

Objective Walkability

The “areas” rated highest in objective walkability by the rater among all sites were the two Downtown sites of San Diego and Ithaca. However, results did not clearly distinguish the older adults in these two Downtown sites to be more physically active. Although none of the differences were statistically significant, calorie expenditure was the only physical activity measurement that was slightly higher among Downtown participants, and Suburban-Rural participants measured marginally higher in physical activity for step count and percentage of trips on foot. These results are surprising because Downtown sites were objectively measured as more walkable. A likely possibility is that Suburban-Rural participants walked more due to other
reasons not associated with the objective walkability of their neighborhood. Further investigation of the subgroup of Suburban San Diego residents revealed that almost all participants in the study partook in biweekly exercise classes held in the apartment facility. Lim and Taylor (2005) in their study of Australian older adults found an independent association with living in a rural area and adequate exercise, and similarly purport higher participation rates in organized sport as well as environmental factors such as more open space and less traffic. The participants from this apartment were practically an all-Asian subgroup who, from observation, knew each other well and did other activities together, such as eating meals. A greater sense of community could be a determining factor, but unfortunately this cannot be assessed because it was not measured among San Diego residents.

Perceived Walkability

The most compelling findings in this study relate to the association between perceived walkability features and physical activity. The perceived neighborhood walkability variable (NEWS) was conducted in Ithaca, NY\(^1\) and relied on the participants’ assessments of their neighborhood in walking distances to destinations, presence of walking and cycling facilities, aesthetics, and pedestrian and traffic safety. With the Ithaca data, regression analysis found several significant predictors explaining physical activity. Because Downtown Ithaca residents rated their neighborhood as significantly higher in the following features of perceived walkability, this suggests that their perceptions positively affected their physical activity results. Although a causal relationship cannot be established, this supports previous research in that a perceived walkable environment is associated with higher physical activity levels (Hoehner et al., 2005; Pikora et al., 2003; King et al., 2003).

\(^1\) Note: The Neighborhood Environmental Walkability Scale (NEWS) was administered only in Ithaca.
The NEWS measurement, “Land use mix – diversity”, asked participants how long it would take to walk to various facilities and businesses, and was the only significant predictor of step count. This explanatory variable makes sense because those who perceived they have more places to walk to within 10-15 minutes would be more likely to walk to them instead of traveling via motorized transport, thus increasing their step count. Previous studies have already found that neighborhoods objectively closer to a downtown area walked more than those in neighborhoods farther away from downtown (Handy et al., 2001). The link between perceived and objective walkability has also been studied; a pilot study which also used the NEWS measurement found that participants’ perceptions of two neighborhoods were related to the objectively assessed walkability score (Leslie, Saelens, Frank, Owen, Bauman, Coffee, Hugo, 2004). The two neighborhoods, objectively rated ‘high’ and ‘low’-walkability, were perceived as significantly different for land-use mix and infrastructure for walking, among other characteristics (Leslie, et al., 2004). A more recent study also found transportation activity to be positively associated with perceived and objectively measured number of destinations (Hoehner et al., 2005).

Perceived “Aesthetics” and “Walking/cycling facilities” variables both had a positive and statistically significant association with calorie expenditure. The aesthetic features that were measured in NEWS, which can be noted while walking in a neighborhood, included being free from litter, having attractive natural sights and buildings, having trees and a tree canopy, and having interesting things to look at. In a review of 18 studies, aesthetics were evaluated among other environmental characteristics and was found to be associated with walking for exercise and recreational purposes (Owen, Humpel, Leslie, Bauman, Sallis, 2004). However, the same review reported that aesthetics were not found to be associated with walking to get to and from a place, a factor that is discussed below under “Walking Purpose”.
The “Walking/cycling facilities” predictor variable - which can be interpreted as the perception that a place has sidewalks and paths that were well maintained, easily accessible, and separate from the streets - was associated with higher calorie expenditure. Similarly, Hoehner and colleagues’ study (2005) also found biking for transportation purposes to be positively associated with perceiving bike lanes to be present on streets. Walking and cycling facilities that are safer and more accessible may have encouraged older adults going about their daily routine outdoors instead of within the residence. Owen and colleagues’ (2004) 18-study review also found that presence of sidewalks was significantly associated with all 3 types of walking: walking for exercise/recreation, getting to and from a place, and total walking (Owen et al., 2004).

The last physical activity measurement, percentage of trips on foot, was best explained by the NEWS variables perceived “Aesthetics” and perceived “Crime Safety”. Crime safety was measured by answering questions related to perceived crime rate as well as seeing and being seen in the neighborhood; this depended on the time of day, if one is walking, and how well-lit streets are at night. Downtown Ithaca residents perceived both Pedestrian/Traffic Safety and Crime safety to be lower (i.e. less safe) than Rural Ithaca residents did in their neighborhood, possibly because of the observed busier atmosphere within downtown sites compared to rural sites. Lower perceived crime in rural Ithaca could also help explain why differences in physical activity results were not significant; the safer atmosphere may have encouraged physical activity despite the less objectively walkable neighborhood. These results confirm findings of previous studies indicating that one’s perceptions of the environment are dependent on individual experiences related to physical activity behavior (Kirtland, Porter, Addy, Neet, Williams, Sharpe, Neff, Kimsey, Ainsworth, 2003).
Walking Purpose

Ahrentzen (2004) differentiated between two walking purposes -- leisure and enjoyment, or destination-oriented movement. In analyses including both Ithaca and San Diego data, the current study found no significant difference in walking purpose between Downtown and Suburban-Rural sites. However, between the two combined sites, Downtown measured higher in destination walking trips, and between the two San Diego areas, the majority of trips in Suburban San Diego were for leisure/enjoyment purposes (Table 6). The results, although not significant, are consistent with earlier studies. Saelens, Sallis, Black, and Chen (2004) found that the percentage of residents walking for errands was significantly higher in neighborhoods of high-walkability than in the low-walkability neighborhood.

The possible reasons that there was no difference in walking purpose between the Downtown and Suburban-Rural older adult participants are multi-faceted, but one point that can be made is that walking for leisure/enjoyment purposes is probably more common among older adults than is walking to a store to shop. Performing errands requires more purpose, energy, time, and planning, i.e. carrying items, whereas walking to enjoy the fresh air requires none besides the motivation to go out.

Travel Mode

Although combined Downtown sites and Suburban-Rural sites found no significant difference between mean percentage of trips on foot, Suburban San Diego residents had a higher percentage of trips on foot than that of Downtown residents. Studying travel mode among older adult participants could have been operationalized differently to include a more accurate examination of this possible explanation for physical activity behavior. During data collection, the Principal Investigator observed that Downtown San Diego has an extensive bus and trolley system that participants of
this study might have utilized during the investigation. In Suburban San Diego, most locals drove cars, and buses were the only public transportation within walkable distance from the residence. One explanation for the disparity could be related to coding of walking trips. For example, if a trip on the trolley included a walk to the trolley station, the trip may not have been coded as multimodal, noting both walking and riding the trolley. Full completion of the travel log was not regulated due to participants’ logging of own data. In this perspective, Downtown San Diego may not have necessarily walked less, but rather coding for travel log data was a construct validity issue. Consistency in conducting the same measurements for all participants, such as conducting the NEWS measurement among Downtown and Suburban San Diego participants, is another improvement to be made in future studies.

**Personal Factors**

Of the descriptive variables, BMI, self-reported health level, incontinence, and difficulty walking were the significant predictors of physical activity as measured by step count per week. After conducting post-interviews with Ithaca residents, most mentioned personal health as a main determinant for walking or not. Chronic ailments, such as a bad back or a sore leg, were some of the reasons mentioned in deciding to walk that day. Our findings support the idea that older adults who report better physical functioning are more active; Lim et al. (2005) found that 72% of older adults reported health problems as the major barrier to physical activity. An international study that examined factors affecting physical activity found that middle-aged women who perceived their health to be poor and had an aesthetically unattractive neighborhood were more likely to regress from leisure-time running (Titze, Stronegger, Owen, 2005). Surprisingly, studies have not found smoking behavior as a determinant factor associated with physical activity (Bauman et al.,
This finding could not be tested in this sample because it had no current smokers.

SES was not a significant predictor of physical activity. This finding may be due to income having little variance among Ithaca participants initially because the downtown and rural residences are HUD (Department of Housing and Urban Development)-subsidized.

Because of the multi-ethnic population in this study, we included a survey question asking participants their native language and to rate their comfort in the English language. The purpose was to assess correlations between physical activity level and acculturation, since previous studies have found this correlate to be strongest in Latino adults in determining obesity (Hubert et al., 2005). Acculturation in terms of communicating confidently the English language was not found to be a significant predictor of physical activity among older adult minorities. However, acculturation may have been related to the ability to travel alone, a variable not measured in the current study. Lim et al. (2005) found the strongest association with adequate physical activity among older adults to be ability to travel independently by car, bus, or train. In addition, fear of using public transportation is not uncommon among older adults (Arhentzen, 2004).

**Strengths**

The strengths in this study were that it examined environmental walkability using both objective and subjective instruments: the CDC Walkability Audit Tool and NEWS. Understanding the two methods, objective and subjective, is important because both may be correlated to physical activity outcome. While objective measures of neighborhood were found to influence physical activity among older women (King, Belle, Brach, Simkin-Silverman, Soska, Kriska (2004), it is also likely
for older adults’ activity levels to be affected by their perceptions. For example, one may perceive his/her environment to be high in crime aspects, even when it is objectively not, and thus not go out after dark. Utilizing both objective and subjective environment measurements can help understand this gap.

The current study also sought to address two understudied and vulnerable populations: older adults and minorities, especially Asian older adults. To accommodate the Korean participants, all instruments, including those for recruitment, were translated into Korean with the help of a fluent Korean-speaker. With the large number of Korean older adults in the San Diego area, this helped tremendously in recruitment. Moreover, the use of written Korean materials made sure that Korean participants understood the study’s purpose and their role in this area of research.

The study measured physical activity variables through three different tools so that the validity of the independent variable would not weigh heavily on one measurement. Furthermore, it included two types of neighborhood data in which older adults live, downtown and suburban/rural, in two separate sites, San Diego, CA and Ithaca, NY, for exploring possibilities in terms of climate, neighborhood, older adults, and physical activity behavior.

Suggestions that were noted from the San Diego study which was done a few months earlier were implemented for the second site’s data collection in Ithaca, as well. The investigation itself was approached at the second site more carefully, such as the PI being more visible to the residents to establish their rapport in the research project. Better organization with data collection and better approachability of the PI increased the quality of personal interaction with participants in the recruitment process, participant retention, and conducting interviews. Additional instruments to the study proved to be useful; the inclusion of NEWS in the Ithaca study was one such addition which produced significant results.
Limitations

One major limitation in this study is the small sample size across all sites and measures. Overall, the recruitment process proved difficult because some of the facilities that were approached with the study showed little interest or reluctance, and thus yielded less participants relative to the facility size. The recruitment methods used were flyers detailing how one could learn more about the study, and one informal talk given in the lobby afterwards. The difference in participation outcome could be for a number of factors, yet the presence and involvement of the service coordinator during the informal talk and the absence of such support at the other site suggests that this could have affected residents’ participation.

Some of the non-significant associations may have been due to the lack of statistical power. The sample of Suburban San Diego participants that recorded for percentage of trips on foot was extremely small (n=2) and these happened to be outliers as well (Figure 7). Studying travel log data found that they walked or jogged daily, and likely affected the already small sample size of Suburban-Rural participants by increasing the mean scores for all three physical activity measurements (Table 3). Another limitation had to do with comparability between groups. T-test results were analyzed for groups of demographic variables and physical activity measurements (Table 9), and chi-square analysis revealed several statistically significant differences between Downtown and Suburban-Rural sites. Ethnicity ($\chi^2 = 10.37, p=.02$), Native language ($\chi^2 = 15.25, p=.00$), English comfort level ($\chi^2 = 10.88, p=.03$), and Incontinence ($\chi^2 = 3.84, p=.05$) might have confounded with site, although we cannot clearly interpret this possibility (Table 7).
Figure 7. Box plot for sites’ mean step count per week
The study’s weather data, which consisted of average high and low temperatures and percentage of days with precipitation, suggests that weather may also have been a confounding variable that explains part of the physical activity results. Between sites mean comparison of temperature found the average high to be significantly higher in Rural and Suburban sites than in the Downtown sites during the recorded travel log days. These results suggest that higher average high temperatures in Suburban San Diego and Ithaca relative to their respective Downtown sites may have positively contributed to walking. Not surprisingly, percentage of days with precipitation was found to be negatively correlated with step count regardless of site (Table 8). These results imply that the less precipitation, the more likely older adults will walk.

Humpel et al. (2002) suggest that a number of seasonal variations such as temperature, humidity, precipitation, and wind may influence physical activity. Because data were collected early in the summer season, humidity could have been an important factor to measure in addition to precipitation and temperature. Post-interviews with Ithaca participants support this possibility. One participant said that if the weather was too hot or humid, it was personally hard to breathe and limited that person to walk indoors. Similarly, another said that the weather determined whether he/she walked inside or outside. Older adult participants in this study seemed to make up for rainy or uncomfortable weather by walking indoors.

Measurement limitations and suggestions

1. Pedometers and Older Adults

Not all older adults are the ideal candidates for the use of pedometers due to several factors that can decrease the accuracy of pedometers. To begin with, age is a factor. Melanson, et al. (2004) found age to be the best predictor for decreased
accuracy. Furthermore, the accuracy of pedometers decreases up to 71% when walking at a pace below 2.0 mph, which can be expected with an older adult population (Melanson, Knoll, Bell, Donahoo, Hill, Nysse, Lanningham-Foster, Peters, Levine, 2004). The PI observed older adults’ tendency to wear their pants above the waist so that the pedometer is placed above the hip bone, and this also could have decreased the ability to read each step correctly.

Moreover, the use of the pedometer is not as easy for this population. Some older adults had difficulty opening the pedometer at first, so training was needed or tape was used to secure the cover open. Furthermore, the pedometer study could have been better controlled if all participants within each site began and finished monitoring on the same days to control for weather conditions. One study stated that the Longitudinal Aging Study Amsterdam (LASA) Physical Activity Questionnaire (LAPAQ) appeared to be a valid and reliable measurement compared to a 7-day diary and pedometer method, as well as easier to use (Stel, Smit, Pluijm, Visser, Deeg, 2004). The consideration of the LAPAQ may be taken into account for future studies assessing physical activity in older people.

An intervention study showed that wearing a pedometer can be a motivational factor to be active, as pedometers have been utilized and shown to significantly increase physical activity (Chan, Ryan, Tudor-Locke, 2004). Perceptions and how they affect self-motivation should be included in any research study on older adults’ environment and physical activity. Controlling for the pedometer as a motivation to walk more is a further step to improving this study. One possibility is to use accelerometers instead, which measure physical activity but do not provide feedback to the wearer.
2. NEWS – Neighborhood Environment Walkability Scale

Some limitations may lie in NEWS, the perceived walkability instrument. Section B: “Stores, Facilities, and other things in your neighborhood”, asked for the time it would take the participant to walk from one’s home to each business/facility. Older adults completing the survey may need to state the average person’s time to walk because older adults may walk at a slower pace. Furthermore, the NEWS questionnaire assumed that participants walked frequently in their neighborhood, and did not take into account those who do not walk at all. Thus, some participants may have guessed their responses for pedestrian safety, crime, etc.

3. CDC Walkability Audit Tool

Because the CDC’s Walkability Audit Tool initial purpose was for workplaces, several suggestions are made. First, this tool could be improved by objectively measuring key destinations in the neighborhood to compare with residents’ perceptions of land use access and diversity. On the same note, because the audit only had one overall score, particular environmental characteristics could not be associated with any physical activity measure. Having sub-scores in the audit to correlate with physical activity measures would be a more accurate method of pinpointing which physical features affect physical activity and walking purpose.

Suggestions for future studies

Future studies involving environment and physical activity of older adults should take into account these following improvements to the current study. The current study has revealed greater emphasis on the relationship between older adults’ perception of their environment and physical activity. A key improvement for future studies, besides more statistical power, is to focus on why neighborhood perception was an important role for older adults to be physically active.
Factors such as self-efficacy, motivation, and personal experience in combination with perceived environmental features could offer more insight into the environmental facilitators and barriers of physical activity.

This study has also highlighted the need to better understand older adults’ travel modes. Studying this population’s methods of getting around and being mobile warrants further research because of issues like acculturation, lack of transportation, and inability to travel alone. An improved travel log that included multimodal coding, purpose of travel, and with whom they traveled might also help in understanding which specific environmental influences are direct correlates of walking.
REFERENCES


