High and low active transit accessibility on greenways: The relationship with physical activity

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I am submitting herewith a thesis written by Dana Lizbeth Wolff entitled "High and low active transit accessibility on greenways: The relationship with physical activity." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Kinesiology.

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HIGH AND LOW ACTIVE TRANSIT ACCESSIBILITY ON GREENWAYS:
THE RELATIONSHIP WITH PHYSICAL ACTIVITY

A Thesis Presented
for the Master of Science Degree
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Dana Lizbeth Wolff
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DEDICATION

To my parents, Lance and Mary Wolff, for their endless love, support, and encouragement.
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ABSTRACT

Greenways (GW) can be sited to increase the potential for individuals to access the GW through active transit (AT) and provide opportunities for individuals to meet PA guidelines. PURPOSE: To determine if GWs, with varying AT access potential, relate to user characteristics and their GW-related PA. METHODS: A trail intercept survey measuring access mode, GW-specific PA, and demographics of GW users was administered to 611 adults on 2 GWs with high and low AT potential (GW<sub>high</sub> vs. GW<sub>low</sub>). RESULTS: Users of GW<sub>high</sub>(N=216) compared to GW<sub>low</sub> (N=400) were more likely to be younger, male, never married, employed, and affluent; accessing the GW via AT modes and accumulating greater volumes of GW-only and total GW-related PA (GW-only & AT PA). No difference in the proportion GW users meeting the 2008 PA Guidelines from GW-only PA was found however, 10.5% more users of GW<sub>high</sub> met the guidelines from total GW-related PA compared to GW<sub>low</sub> (p=0.039). Users who accessed GW<sub>high</sub> by AT rather than cars were more likely to be not married (OR=2.6, 95% CI: 1.1 – 6.3), under 35 years old (OR=6.0, 95% CI: 1.9 – 19.26), live a mile from the GW (OR=5.39, 95% CI: 2.3 – 14.3). CONCLUSION: The profile of GW user and the way PA is acquired is related to the AT accessibility of GWs. Although PA levels of GW<sub>high</sub> users were significantly higher, GW<sub>low</sub> usage was greater. Therefore, GW planners and designers should incorporate universal design concepts and conduct needs based assessments to properly site and design GWs to serve the greatest portion of the population.
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CHAPTER 1

Introduction

Over recent decades, rates of sedentary lifestyles have risen to epidemic proportions [1, 2]. Many researchers and public health officials believe that a key in combating the epidemic of physical inactivity is to change the built environment (BE) in which individuals live to promote physical activity (PA) [3-5]. As early as 2002, legislative and policy makers recognized the need for increased access to places to perform PA within the BE. As a result, documents such as The Community Guide, Healthy People 2020, and the 2010 National Physical Activity Plan include objectives that recognize the need for communities to increase PA opportunities for individuals in the BE by enhancing access through environmental and policy interventions [6-8]. Specific recommendations included within these documents include tactics to enhance traffic safety in PA areas, encourage “complete street” and “livable community” policies and design, and increase connectivity and accessibility to community destinations [6-8]. These recommendations are ultimately thought to increase both transportational and leisure-time PA.

Greenways (GW) present one way to meet the PA recommendations; providing individuals, neighborhoods, and communities with opportunities to engage in outdoor leisure-time and transportational PA [9]. Ideally, GWs are sited near population centers and places for commercial land use in a manner to create “mixed land-use” environments that provide opportunities to run errands, shop, etc.; in addition to leisure-time PA [10]. An example of this type of GW can be seen in the Third Creek GW in Knoxville, Tennessee which is located in a well-established area of mixed land use. The GW provides multiple destination points along its path including neighborhoods, businesses, schools, and other public facilities [11, 12]. The
siting of this GW within the BE also provides users the opportunity to access the GW via active transit (AT) to perform either leisure time or transportational PA. GWs can also be sited, perhaps not deliberately, in manners that minimize access of individuals to the GW through active transit (AT). One example of this type of low-AT access GW can also be found in Knoxville, TN. Lakeshore GW is a stand-alone GW that is not integrated into the surrounding residential land-use and is distant from commercial land use parcels [13]. Lakeshore GW is also surrounded by a fence and borders two heavily trafficked roads that lack sidewalks or crosswalks. Individuals who live close to a GW may therefore have to take passive forms of transportation, like automobiles, to access the GW.

Currently, Knoxville, TN has constructed 36 GWs that total 41.9 miles in length [11]. These GWs were designed in either a linear, loop, or mixed linear-loop fashion and sited in either residential, commercial, or mixed commercial-residential land use. In a review of the 2009 GW master plan, it was found that 50% of constructed GWs in Knoxville are circular, 44.5% are linear, and 5.5% are mixed linear-loop in nature. In terms of GW siting, 36.1% of GWs were located in residential areas, 13.9% in commercial areas, and 50% in mixed commercial-residential land use areas [11]; reflecting high and low opportunities to access through AT. To date, no studies have been done to compare the siting of the GWs in relationship to user characteristics and their PA behaviors. Therefore, the purpose of this study was to determine if two GWs, with varying potential of AT access (high vs. low), relate to user characteristics and their PA behaviors. Two GWs that were hypothesized to have high and low AT potential were selected for this investigation. One GW mirrored the 2010 National Physical Activity Plan as it was based upon a foundation of a livable community and strived to meet complete street standards; allowing high potential to access via AT modes. In comparison, the
second GW chosen for this study had low potential for individuals to access via AT due to barriers surrounding the GW such as high volumes of traffic and streets that lacked sidewalks and crosswalks. It was hypothesized that GW accessibility would be related to how users accessed the GW with users of the high-accessible GW compared to the low-accessible GW more likely to access the GW via AT modes.

**Definition of Terms**

1. **Greenway (GW):** “A system or network of interconnected lands (patches and corridors) that are planned, designed and managed for multiple purposes, including: ecological protection, recreation, and cultural/historic landscape value(s) [14-16].”

2. **Active-Transit Accessibility (AT):** An objective measure (high vs. low) denoting the ease with which activities may be reached from a given location using a particular form of active transit (i.e., walk, jog, bike) [17].

3. **High AT Accessibility:** Represented by GW\textsubscript{high}, a continuous linear GW located within mixed land-use and having multiple points of access.

4. **Low AT Accessibility:** Represented by GW\textsubscript{low}, a discontinuous, circular GW located in a residential area and surrounded by a fence, with only two access points from heavily trafficked roads having no crosswalks or sidewalks.

5. **Complete Streets:** Streets designed and operated to accommodate safe access for pedestrians, bicyclists, motorists, and public transportation users, creating a multimodal transportation networks [18].

6. **Livable Community:** “A community that has affordable and appropriate housing, supportive community features, and services, and adequate mobility options, which
together facilitate personal independence and the engagement of residents in civic and social life [19].”

Statement of the Problem

This study examines the relationship between GW accessibility through AT, defined by linearity and continuity, and leisure-time and transportational PA behaviors of GW users in Knoxville, Tennessee. Accessibility was examined using GW\textsubscript{high}, a highly accessible GW, and GW\textsubscript{low}, a low accessible GW. Emphasis was placed on the relationship between total GW PA and AT accessibility and acquired MET·min·wk\textsuperscript{-1} on the GW. The following research questions reflect the purpose of this study.

Research Questions

1. Is there a difference between user characteristics of high and low AT accessible GWs?
2. Is there a difference between the mode of access (e.g. car, walk, and bike) among users of high and low AT accessible GWs?
3. Does the PA profile specific to leisure-time and transportational PA on the GW differ between high and low AT accessible GWs?

Significance of the Study

This study will be the first to examine how GWs sited with low and high potential for AT access within the BE relate to PA behaviors of GW users.

Delimitations

The study population was limited to consenting adult GW users on the Third Creek (GW\textsubscript{high}) and Lakeshore (GW\textsubscript{low}) GWs in Knoxville, Tennessee. Consenting participants were comprised of GW users who were English speaking adults over 18 years of age, using either GW
during the time of the survey administration period. This study is delimited to only leisure-time and transportational PA performed on the GW.

Limitations

The present study has several limitations inherent within its design. Therefore, the findings and the discussion of in this study must be interpreted with caution. The limitations of this study are listed below:

1. This study was confined to three months of data collection.
2. The use of a convenience sample and an incentive may not provide a true representation of the GW population being studied.
3. PA was measured by a self-report interview and thus is subject to recall bias.
CHAPTER 2

Review of Literature

2.0 Introduction

Environmental approaches to enhance the built environment (BE) have been recognized as a method to increase physical activity (PA) [4, 5, 20]. Greenways (GW) are “systems or networks of interconnected lands (patches and corridors) that are planned, designed and managed for multiple purposes, including: ecological protection, recreation, and cultural/historic landscape value(s)” [14-16]. The development of greenways (GW) are one method to increase PA it increases opportunities for individuals to engage in outdoor leisure-time and transportational PA [9]. Along this line, the siting and design of GW are important as they may influence the type of user and their related PA behavior [21-27].

The following review of the literature will discuss: 1. Physical inactivity within the United States; 2. National objectives to increase access to physical activity specific to the built environment; 3. The relationship of the built environment on physical activity; and 4. A review of all the studies that have examined the relationship between GW siting and design and PA patterns of GW users.

2.1 Physical Activity

Regular physical activity (PA) is positively associated with a reduced risk of all-cause mortality [3, 20, 28] and morbidity of chronic diseases including cardiovascular disease [29, 30], type 2 diabetes [30, 31], and colon cancer [32]. Despite the benefits of regular PA, which include improved health status and quality of life, only 40% of the global population accumulates enough PA to achieve health benefits [33]. Within the United States the level of
physical activity is significantly lower with only 20% of adults meeting national guidelines for both aerobic and resistance training activities [6, 34]. The health burden associated with physical inactivity is astronomical, with approximately 300,000 lives lost due to physical inactivity each year [2, 35]. As well, the medical costs related to physical inactivity are extremely high averaging $76 billion dollars per year [3].

2.1.1 Physical Activity Guidelines

Current PA recommendations have been established through the 2008 Physical Activity Guidelines for Americans [34]. These guidelines provide science-based recommendations to improve the health status of Americans over the age of 6 through PA. In order to attain health benefits from PA, the guidelines recommend adults achieve 150 minutes per week of moderate intensity PA such as walking briskly or biking; or 75 minutes of vigorous intensity PA such as jogging or sports. It is recommended that exercise sessions be broken up over the course of the week, where individuals would exercise 30 minutes to an hour, three to five days per week [34]. Recommendations for weight loss state that individuals should attain twice the amount of PA recommended for health benefits. Individuals aiming to lose weight should therefore accumulate either 150 minutes per week of vigorous intensity physical activity or 300 minutes of moderate intensity physical activities [34].

PA can be accumulated through numerous activities that are classified into four domains: leisure-time, occupational, domestic, and transportational [36]. Leisure-time PA is defined as activities performed at an individual’s leisure such as: recreational activities, exercise, and sports participation. Occupational PA is composed of all activities performed at work, such as carrying heavy loads or boxes or operating machinery. Domestic PA includes activities performed in an
individual’s home such as lawn care, home repairs, or cleaning. Transportational-related PA is defined as walking, jogging, or biking to-and-from work or school or while running errands [36].

2.2 Environmental Approaches to Increase Physical Activity

Environmental approaches for increasing PA recognize the interrelationship between an individual and their built environment (BE). Research indicates that factors within the BE are a primary determinant of physical activity [7, 37-39]. Therefore, many researchers and public health officials believe that a key to increase PA is to change or better plan the built environment (BE) in which individuals reside to promote PA. As well, the implementation of these BE approaches and interventions potentially have a greater impact on PA as they have greater reach and are more cost-effective than individual approaches to increase PA [7, 20, 40-42].

Specifically, Healthy People 2020, The 2010 National Physical Activity Plan, and The Guide to Community Preventive Services include BE approaches and objectives aiming to increase PA.

2.2.1 Healthy People 2020

Healthy People 2020 provides science-based, 10-year national health promotion and disease prevention objectives for improving the health of Americans [6, 43]. Healthy People 2020 includes numerous objectives across areas of public health including PA. The overarching goals of these objectives are to “attain high-quality, longer lives free of preventable disease, disability, injury, and premature death; achieve health equity, eliminate disparities, and improve the health of all groups; create social and physical environments that promote good health for all; and promote quality of life, healthy development, and healthy behaviors across all live stages” [6, 43].

Specific to PA, the focus of the Healthy People 2020 objectives are to increase the amount of moderate or vigorous PA performed by Americans and increase PA opportunities for
individuals by enhancing access through environmental and policy approaches [6]. This is reflected in two objectives, PA-13 (increase the proportion of trips made by walking) and PA-14 (increase the proportion of trips made by bicycling) which aim to increase the proportion of trips made by walking and bicycling in adults and children. Objective PA-15 also focuses on the BE with a goal to “increase legislative policies for the BE that enhance access to and availability of PA opportunities” [6].

The aforementioned objectives are new to the PA section of Healthy People and are therefore considered developmental. Due to the developmental status of these objectives, no baseline measures have been reported and data sources to measure these outcomes have not been established. Instead, each objective lists potential data sources which include the National Household Travel Survey (NHT), Department of Transportation (DOT), and Federal Highway Administration (FHWA) for PA objectives 13-14 and the CDC Division of Nutrition, Physical Activity, and Obesity Legislative Database for PA objective 15 [6].

2.2.2 The 2010 National Physical Activity Plan

Launched in May, 2010, the 2010 National Physical Activity Plan [8] provides a way to achieve PA objectives included in Healthy People 2020. The plan aims to create a culture within the United States that supports an active lifestyle. Based on evidence included in research documents such as the Community Guide, the plan includes policies, programs, and initiatives to increase PA that have been organized into eight sections: business and industry; education; health care; mass media; parks, recreation, fitness, and sports; public health; transportation, land use, and community design; and, volunteer and non-profit. Each section includes strategies and tactics for promoting PA. Specific to increasing opportunities to access areas for PA within the BE, the Plan includes strategies to increase connectivity and accessibility to community
destinations to increase both leisure time and transportational PA. Potential tactics to accomplish these strategies include: enhanced traffic safety in PA areas, support and increased incentives for projects that create safe and accessible active transportation networks, and encourage the adoption of “complete streets” and “livable communities” through planning, design, and development policies [8].

2.2.3 The Guide to Community Preventive Services

Developed by the nonfederal Task Force on Community Preventive Services (the Task Force), the Guide to Community Preventive Services (the Community Guide) provides recommendations for public health practitioners and decision makers to improve the health and disease status of communities. Using systematic reviews, the Community Guide aims to promote evidence-based public health practice within 15 topic areas that “encompass Healthy People objectives, have a broad scope of problem areas and related interventions, address risk behaviors with the largest collective impact on health, and address major causes of morbidity and mortality across the lifespan” [44].

Physical activity, one topic area included in the Community Guide, includes reviews of environmental and policy approaches designed to increase opportunities, support, and cues for individuals to improve physical activity levels of communities [28]. Three types of environmental and policy based interventions were reviewed by the Task Force: community scale urban design and land use policies, street-scale urban design and land use policies, and transportation and travel policies and practices.

Sufficient evidence for the implementation of community scale and street scale urban design and land use policies was found by the Task Force. Community scale design and land use policies involve changing or developing large areas of land, from several square miles to entire
communities, to promote PA. On the other hand, street scale policies typically change or develop small areas of land that are limited to a few blocks such as street segments. Specific design elements found to promote PA at the community level include the proximity of residential areas to jobs, schools, recreation, and commercial areas; continuity and connectivity of streets and sidewalks; and safety and aesthetics of the BE. Similarly, street-scale design components that promote PA include improved street lighting, infrastructure projects to increase the safety of street crossings, use of traffic calming approaches, and enhanced street aesthetics. Policies that can be implemented at the community and street scale are similar and include: zoning regulations, building codes and practices, roadway design standards, and governmental policies [20, 28].

The Guide also identifies interventions utilizing transportation and travel policies and practices aim to increase PA through improving pedestrian and cyclist’s activity and safety, increasing access to public transportation, reduce car use, and improve air quality. Environmental changes to achieve these goals include creation or enhancement of bike lanes, expansion of public transportation, increased parking costs, etc. Interventions utilizing these policies and practices have the potential to increase green space and commerce, improve air quality, and decrease stress. However, due to a limited number of studies within this area, insufficient evidence for transportation and travel policies and practices was found by the Task Force for inclusion in the Community Guide.

2.3 Greenways & Physical Activity

A GW is commonly defined as a “system or network of interconnected lands (patches and corridors) that are planned, designed and managed for multiple purposes, including: ecological protection, recreation, and cultural/historic landscape value(s)” [14-16]. Since the
1980s, the building and use of GWs have become popular both nationally and internationally [24]. The construction of GWs also provides communities with a venue for outdoor physical activity (PA), especially walking and cycling, the two most common modes of PA [45, 46].

Although the construction and use of GWs in the promotion of physical PA has increased in our society, factors within the BE impacting GW usage are not well understood [2]. This is important to urban planners and public health officials, as policies and strategies to increase access to facilities, such as GWs, through active transport, are a potential way to attain Healthy People 2020 PA objectives.

2.3.1 History of Greenways

The history of GWs dates back to 1866 when Frederick Law Olmstead, the father of the GW movement, proposed the development of the linear Park Way GW in Brooklyn, New York [14, 15]. In his proposal to Brooklyn in 1866, Olmsted urged the creation of a “shaded pleasure drive” to connect from Prospect Park to Coney Island. One of the first GWs in America, this GW is now part of the Brooklyn-Queens GW, in New York City [14].

The development of trails and GWs continued during the late 19th Century and into the decade of the 1960’s in the 20th Century throughout the United States in what Searns calls the “Social-cultural/Recreational GW movement” [16]. Up until 1950, the term “greenway” had not been used, however the system of trails and networks we now know as GWs were used by cities for their recreational and aesthetic qualities. Specifically, GWs of this period served three functions: an escape from urban areas, vision-experience (i.e. aesthetics), and an opportunity for leisure time activities [16].

In the 1960’s through the early 1980’s, the environmental attributes of GWs became an important concern marking the “Ecological GW movement” [16]. During this time period, the
goals of GW planning shifted to the preservation and protection of wildlife, natural resources, and stream corridors and ridges. While the recreational aspects of the GW remained intact, GWs developed during this period included natural amenities that allowed users to enjoy nature [16].

Encompassing aspects of GWs developed during the Social-cultural/Recreation and Ecological GW movements, the development of multi-objective GWs began in 1985 and has continued into the 21st Century [16]. During this time period the “contemporary GW movement” was nationally recognized for the first time by the 1987 President’s Commission of Americans Outdoors, which recommended the “establishment of a network of GWs across America” [15]. The development of “multi-objective GWs” are important as they include both recreation and ecological attributes and utilize information from a wide variety of disciplines for planning and design that were previously disconnected, including landscape architecture, civil engineering, ecology, and kinesiology [16].

2.3.2 Knoxville Greenways

The development of a GW system in Knoxville, Tennessee began in the early 1970’s with the construction of the Third Creek Greenway [11]. This GW initially provided a connection between the University of Tennessee Married Student apartments and the University’s campus [12]. In 1994, the city and county recognized a need to increase recreation and green space and in response a comprehensive, countywide GW master plan was developed. The plan aimed to “supply public park facilities while providing for the preservation of some of Knox County’s most important natural resources [11].” As a result of this plan, Lakeshore GW, was built in 1996, after the Tennessee Department of Mental Health and Developmental Disabilities downsized the Lakeshore Regional Mental Health Institute and allocated the land to the City of Knoxville [13].
Since the development of Lakeshore in the late 1990’s, the city has constructed 36 GWs that total 41.9 miles in length. In a review of the 2009 GW master plan, it was found that 50% of constructed GWs in Knoxville are circular, 44.5% are linear, and 5.5% are mixed linear-loop in nature. In terms of GW siting, 36.1% of GWs were located in residential areas, 13.9% in commercial areas, and 50% in mixed commercial-residential land use areas [11].

Currently, GW plans in Knoxville include the development of GW connectors both within the county and regionally to create a comprehensive GW system throughout the city and region of East Tennessee [11]. The design of these connectors will depend on several factors including the right-of-way width, intersection or driveway frequency, land-use, population served, and traffic volumes. While the plan does not specifically cite these factors as potential accessibility barriers, the overall goal of the GW plan is to increase public access to GWs through the development GW connectors [11].

2.3.3 Relationship between Opportunities to Access Greenways and Physical Activity

The built environment (BE) is a multidimensional concept that encompasses human activity within the physical environment. Accessibility, one aspect of the BE, is defined as the degree to which the environment is made available to people. Within the BE, accessibility has commonly been reported as a factor related to outdoor PA [37]. Specifically, research indicates that an individual is twice as likely to engage in outdoor PA if he or she perceives they have access to PA [47]. GWs are one component of the BE that have become increasingly popular, providing individuals within the community where they are located opportunities to engage in outdoor leisure-time and transportational PA [9]. Studies suggest several factors of the BE and GW use are related to opportunities to access areas to perform PA including: proximity to
destinations (e.g. schools, stores, work, etc), connectivity of street networks, completeness of streets, and land use mix [5, 39, 47-49].

2.3.3.1 Methods Used to Assess Indicators of Accessibility Greenways and Physical Activity

Studies measuring indicators of GW accessibility have used two different data sources. Census data and Geographic Information Systems (GIS) are two different methods used in measuring the opportunity to access GWs. Population data from the Census has been used to calculate the density of people or population density and the demographic composition of individuals living around a GW [22, 23, 26, 27, 50, 51]. Demographic data from the Census is then used to determine whether GW users are representative of the city or county where the GW is located. Additionally, parcel data has been used to calculate the land use mixture around the GW.

GIS is one tool that can be used to calculate indicators of accessibility [21-24, 50, 52-55]. Although GIS typically uses Census data, this information is linked to a map that contains various geographic data such as road networks. This allows researchers to more accurately determine the population density, demographic characteristics, and land use mixture surrounding a GW. Specifically, buffers are typically created to determine how these characteristics vary within different radial distances around the GW (i.e. 0.25 or 0.5 miles around a GW).

Researchers can also use GIS to calculate the distance individuals live from the GW using geocoding. In the process of geocoding, address or intersection data provided by respondents is matched to the road data for the map and plotted as an individual point. Distance is then calculated using one of two different methods, Euclidean and road network distance, both of which have been utilized by researchers [21-24, 50, 52-55]. Specifically, Euclidean distance is calculated using the shortest distance between the geocoded address and the nearest point of
the GW. The second measure is the road network distance, which calculates the distance from the geocoded address to the closest point of the GW using the street network an individual would have to travel to access the GW. This method is used more often as it provides a better estimation of proximity.

GW user characteristics and PA behaviors have been measured using one of three methods: trail counters, direct observation, or surveys. Trail counters allow researchers to monitor use of the GW over long periods of time [26, 27]. One major drawback to this method, however, is that it does not provide researchers with any information regarding the GW user characteristics or their PA behaviors. Direct observation provides more insight to GW use as it allows researchers to determine characteristics of GW users and the types of PA being performed on the GW [10, 24, 50]. While instruments such as the System for Observing Play and Recreation in Communities (SOPARC) have been validated, the data obtained from these instruments do not allow total PA to be calculated. In addition, the time required to perform direct observations is a major drawback for researchers.

Surveys, however, address the limitations posed by trail counters and direct observation methods [9, 21-23, 26, 51-53, 55-60]. Previous research has used several types of surveys including: phone, mail, and trail intercept [9, 21-23, 26, 51-53, 55-60]. Phone and mail surveys typically use a random sample of individuals residing within a certain distance of the GW [21-23, 52, 53, 56-58], whereas a trail intercept survey is conducted on the GW, thus capturing trail users only [9, 26, 51, 55, 57-60]. In order to calculate total PA, surveys include questions related to mode, frequency, and duration of activity [9, 21-23, 26, 51-53, 55-60]. Common units used to measure a respondent’s reported PA include minutes per week [52, 53] and Metabolic Equivalent (MET) hours or minutes per week spent in PA [21]. Some surveys
also allow respondents to classify their domain of PA as either leisure time or transportational [21, 26, 53, 55].

The aforementioned methods are commonly used in studies investigating indicators of GW accessibility, user characteristics, and PA. Specific to GW user characteristics and PA, the methods discussed are used to measure overall trail use, demographic characteristics of users, and PA behaviors (i.e., frequency, duration, mode, and domain). In terms of GW accessibility, studies most commonly use these methods to measure the following indicators of accessibility: proximity, street connectivity, complete streets, and land-use mix. Results of studies using these methods are discussed in the following sections of this chapter.

2.3.3.2 Proximity to Greenway

Proximity is commonly defined as the distance individuals must travel to reach a destination or the population or facility density surrounding an area [24]. Research investigating GW proximity and PA indicates that individuals living within close GW proximity are more likely to access the trail or GW [10, 22, 23, 50, 52]. This was shown in a study by Abildso et al who found that perceived proximity to and use of a rail-trail was associated with differences in psychosocial barriers to PA and perceived neighborhood walkability [52]. A telephone survey was conducted and included questions to measure respondent’s level walking and weekly duration of moderate to vigorous PA, both on and off the rail-trail. Additionally, the survey contained questions to assess psychosocial barriers related to PA including neighborhood walkability and perceived distance from the rail-trail. GIS was also used to measure the number of users within a 0.5 and 1.0 mile radius of the GW [52]. Results from this study indicate that individuals who believe they lived close to the rail-trail report fewer psychosocial barriers to PA and higher neighborhood walkability. Specific neighborhood factors significantly related to
perceived distance included: sidewalks, streetlights, enjoyable scenery, walking/jogging trails, and numerous people exercising in the neighborhood. When looking at the PA levels of these users, however, similar levels of walking and moderate and vigorous PA were accumulated, regardless of the individual’s perceived proximity to the rail trail [52].

Studies conducted by Troped et al in 2001 [22] and 2003 [23] indicate proximity to GWs is related to the amount of time spent performing PA. In both studies, the Arlington Physical Activity and Bikeway Survey was mailed to a random sample of adults listed in the 1997 Arlington, Massachusetts town census. The survey included four questions that were used to determine a respondent’s average recreational and transportational PA, in minutes per week, over the past four weeks. GIS was also to calculate the road network distance from the survey respondent’s home to an access point to the GW, the street elevation or steepness, and determine whether users crossed a busy street to access the GW.

Results from the 2001 [22] Troped study found that users were two times more likely to access the GW if they did not have to cross a busy intersection or the street slope was less than 10% for a continuous distance of 100 m or more. As well, GIS measured distance to the GW was shorter for users compared to non-users (0.43 ± 0.26 vs. 0.58 ± 0.28 miles) with bikeway use for both users and non-users decreasing by 42% for every 0.25 mile increase in the distance from home to the GW [22]. These results were supported by data from the 2003 [23] study which found that distance to the rail trail had an impact on transportational PA. Specifically, results indicated that each additional mile an individual lived from the rail-trail resulted in a decrease of 54.65 minutes per week of transportational PA [23]. However, these results did not extend to recreational PA. The authors indicate that the various activities used to measure recreational PA
may not be influenced by changes in the physical environment thus resulting in this insignificant relationship [23].

The aforementioned studies contrast those of Evenson and colleagues [53] who found proximity to a recently built multi-use trail did not impact transportational or leisure-time PA levels of respondents. A randomized telephone survey was conducted before and after building the multi-use trail. Levels of walking and biking for leisure and transportation, as well as moderate and vigorous PA, were assessed using questions from the 2001 Behavioral Risk Factor Surveillance System (BRFSS). Using GIS, the Euclidean (i.e. shortest) distance to the multi-use trail from participant’s home address was calculated. Although all users lived within 2 miles of the development of the multi-use trail, this did not significantly increase PA. One potential explanation for this result is the method used to measure proximity and PA. Specifically, the calculated distance from user’s homes to the trail may have actually been greater than 2 miles, as the Euclidean distance does not take into account the road network that would be used to travel to the trail. Also, the sample was not large enough to detect interactions between PA and distance to the trail [53].

GIS was also used by Reed et al [50] to measure how far individuals live from trails. Reed et al randomly sampled 430 observed users of a rail trail in South Carolina, asking respondents to identify the nearest major intersection to their home [50]. GIS calculated road network distances from the rail-trail to major intersections found that users resided approximately 2.89 miles away from the rail-trail with no significant differences between gender and ethnicity [50]. It is important to note that a major limitation of this study was the relationship between GW proximity and use was not assessed.
Studies using self-reported distance also indicate trail and GW users, for the most part, live within a close proximity of the GW [50, 51, 53, 55]. Specifically, Troped and colleagues [55] administered a trail intercept survey on two trails: one in Indiana and another in South Carolina. A survey question asked respondents to classify the amount of time it usually took to access the trail from home into one of 3 categories: less than 15 minutes, 15 – 29 minutes, and 30 minutes or more. Another question asked users how far, in miles, they traveled from home to access the trail. Results from the survey indicate the mean distance traveled to access the trail from home was 3.77 ± 6.79 miles with 85.2% of respondents reporting they lived less than 15 minutes from the trail [55]. Furuseth et al [51] also used survey that included close-ended questions related to the locational characteristics of Capital GW users in Raleigh, North Carolina. Survey results indicate 58% of users report living within 5 miles and 90.4% report residing within 10 miles of the GW [51].

Studies also indicate that the surrounding population density, a measure of proximity, can be used to predict levels of GW use [21, 24, 27]. Two of these studies indicate that GWs located in areas of higher population density have greater usage [21, 27]. One of these studies was conducted by Lindsey et al, which used 30 infrared trail counters located on five different trails to measure trail traffic. Corresponding Census block population estimates were then used to compute the gross population density for each trail. Results indicated a positive relationship between population density and trail usage, with a 2% increase in trail use for every additional 100 persons per square kilometer [27]. Similar results were seen in a study by Dunton et al who found trail users were more likely to live in areas of higher population density than non-users. Increased population density was also found to be related to increases in transportational PA performed on the trail. In comparison to the study by Lindsey et al [27], this study used
accelerometers to measure PA and GIS to measure the gross population per acre falling within the trail [21].

Contrasting results were reported by Coutts [24] who used direct observation to determine the PA of GW users and GIS measured road network distance to estimate the density of people living within a 10-minute walking, bicycling, or driving-trip of two GWs. Specifically, results of this study were mixed, indicating population density was not related to walking or biking on a GW in Lansing, Michigan, but were related to decreases in GW-related walking and bicycling on the Battle Creek GW in Michigan [24]. The authors hypothesize the location of these GWs within a park is a potential explanation for these results. Specifically, the authors indicate that the use of parks are an important component for boosting GW use for PA, however, parks are associated with low population densities. Therefore, the GW may have increased use due to the attractiveness of parks for PA, however the low population density of this area produces results opposite of what would be expected [24].

2.3.3.3 Street Connectivity

Another indicator of accessibility is street connectivity, which is defined by the connectivity of street networks or the directness of and access to alternative routes within a street network [61-63]. Higher street connectivity is characterized by a higher number of intersections, few dead end streets, and smaller blocks [61, 63, 64]. Three factors of the BE commonly used to measure street connectivity include intersection density, link-node ratio, and road type/classification [62-64]. Intersection density is calculated as the number of intersections with three or more true intersections within a buffer area. The link node ratio is calculated by dividing the number of street segments by the number of intersections within a buffer area.
While research investigating the relationship between street connectivity and GW usage has not been conducted, studies have found a relationship between the street connectivity within the BE and PA [61-66]. In one study, the relationship between street connectivity and PA was found to vary between the individual and neighborhood level of urbanicity (i.e. the degree to which an area is urban) [61]. Specifically, Hou and colleagues found that at the individual level, the only association between street connectivity and PA occurred in high urbanicity areas. Hou’s study also investigated the relationship between street connectivity and PA at the neighborhood level finding a positive association between street connectivity and PA in both high and low urbanicity areas. Specifically, in low urbanicity areas, intersection density was positively associated with the increased frequency of walking, biking, and jogging of all subjects. Local road density was also found to be positively associated with increased PA in males. An inverse association, however, was found in high urbanicity areas where it was found that as local road density and the local to total roads ratio increased, PA decreased in women [61]. Similar results were also found in a study investigating PA levels of adolescents, which found that the association between street connectivity and PA varied by urbanicity and gender [65]. Additionally, a study using data from 10 U.S. metropolitan areas and found higher levels of street connectivity were related to increased odds of walking [66].

2.3.3.4 Complete Streets

Research investigating the relationship between complete streets and GW use have not been conducted, however, studies on the BE indicate complete streets impact opportunities to engage in PA within the BE. Laplante and colleagues (2008) defined a complete street as “a road that is designed to be safe for drivers, bicyclists, transit vehicles and users; and pedestrians of all ages and abilities” [18]. The presence of bike lanes [4], sidewalks [23], and trails [21]
within one’s environment is related to higher levels of both leisure time and transportational PA. Similarly, road-side benches or seating have been shown to be an important factor impacting the walking levels of older adults [67].

2.3.3.5 Land-use Mix

Land-use mix, another indicator associated with accessibility in the BE, is defined as the commercial and residential composition of different land uses within a certain area [24]. Limited research exists investigating the relationship between land-use mixture and GW use. Of the studies that have been conducted, all have found that the surrounding land-use mixture is related to GW use [10, 22, 24, 27]. This research indicates that overall GW usage tends to be higher in areas of commercial land use [10, 22, 24, 27]. This was seen in a study by Lindsey et al [27], which used parcel-level data for the City of Indianapolis, Indiana to determine the land-use mixture of trails. Results of this investigation indicated that for every one percent increase in commercial land-use, the natural log of daily trail counts increased by 0.0465 [27]. Similarly, Troped et al found that respondents of the Arlington Physical Activity and Bikeway Survey describing their neighborhood as residential were half as likely to use the Minuteman Bikeway than those who indicated their neighborhood was located in mixed residential/commercial or commercial areas [22]. In a study by Coutts [24], the percentage of single-family residential, multifamily residential, commercial, industrial, park, open land, church, and school areas within both a quarter and half mile road network distance from the GW was measured. Comparing the land-use mix to observed GW-related PA, it was found that increased land-use mixture was related to higher levels of GW-related walking. As well, an interaction between land use and population density was found to exist, with higher levels of both walking and bicycling resulting in areas with greater levels of both population density and land-use mixture [24].
2.3.4 GW User Characteristics

Previous GW research described above has also focused on the demographic characteristics of GW users [9, 10, 22, 27, 49-51, 56-59]. Using trail intercept or telephone surveys containing demographic questions, researchers have consistently found that GW users tend to be more affluent, educated, and Caucasian adult males [10, 22, 27, 49-51, 56-59]. Studies also indicate that the demographic composition of GW users is not reflective of the corresponding city, county, or Census Tract demographics [9, 22, 50, 51, 57]. This comparison is typically made using demographic statistics published for the city, county, or Census tract for which the GW is located. In a study by Reed et al. it was found that the percentage of female and minority GW users were lower than the corresponding Census Tract for the GW [50]. Similar results were found in a study by Troped and colleagues who compared the demographic characteristics of GW users to population data for Arlington, Massachusetts where the GW is found. Specifically, it was found that although the racial and ethnic composition of GW users was comparable to the population surrounding the GW, there were a higher percentage of survey respondents who had a college degree (60 vs. 40%) [22]. These skewed demographic variables reflect potential disparities in GW use [9, 57].

2.3.5 PA Behaviors of GW Users

Several studies have investigated GW-related PA behaviors of users. Studies investigating the domain of GW-related PA (i.e. recreation vs. transportation) have consistently shown GWs are most commonly used for recreational purposes [22, 23, 25, 26, 55, 57, 60]. In terms of the mode of GW-related PA (i.e. walking, biking, jogging, etc.), studies indicate that walking and biking are the most common modes of GW-related PA [9, 21, 23, 53, 55, 59, 60], however, these modes occur at different proportions between studies. As well, studies indicate
that most users drive to access the GW [9, 55, 60, 68] and are alone while using the GW [57, 59]. The frequency of GW-related PA has also been similar across studies with many reporting users accessing the GW 3 or more days per week [22, 55, 60]. The time spent on the GW varies between studies, however, the reported time users spend on the GW ranges between 30-60 minutes for each GW visit [22, 55, 60]. The total PA accumulated by users on the GW has also been investigated. Results of a study looking at the total PA accumulated by users on the GW found that average weekly level of recreational and transportational GW-related PA was 8.82 and 3.10 MET-hours, respectively [21].

GW-related PA, particularly intensity, has been found to be impacted by the characteristics of GW users. In a study by Gobster (1995), it was found that individuals 18-38 years old were approximately 15 times more likely to be highly active than users over 55 years old and twice as likely than those under 18 years old [9]. As well, it was found that white users engaged in higher intensity PA on the GW when compared to non-whites [9]. These results were supported by Reed and colleagues who found that men and white users were more likely to be vigorously active than females and non-whites, respectively [50].

2.3.6 Future Research

The aforementioned studies provide insight into the relationship between opportunities to access GWs, GW use, and the demographic characteristics and PA behaviors of GW users. In terms of accessibility, previous research has found that factors such as proximity and land use mix relate to GW use. However, research investigating the relationship between complete streets and street connectivity and GW use has not been conducted. As well, there is currently no research investigating how opportunities to access GWs via active transit modes (i.e. walking, jogging, and bicycling) are related to GW user characteristics and their PA behaviors.
Siting and design are two factors that may be related to opportunities to access GWs; however, research investigating this relationship has not been conducted. This is important to urban planners and public health officials, as it is unknown whether the siting and design of GWs within the BE is related to GW user characteristics and their related PA behaviors both on and off the GW. Additionally, it is unknown whether siting GWs in areas that have greater opportunities to access, especially via AT modes, is related to higher levels of GW-related PA.

In studies investigating the PA of GW, the total PA of participants or GW trail counts are used to quantify PA, not total volume of GW-related PA (i.e., MET-minutes-week\(^{-1}\)). To our knowledge only one study has been conducted quantifying total GW-related PA [21]. However, the sample of this study consisted of both users and non-users of two GWs that were located within a half a mile of respondent’s homes. Due to the area constraints of the sampling technique, the relationship between the distance respondents lived from the GW and GW-related PA could not be assessed.
CHAPTER 3

Methods

Introduction

This study utilized a cross-sectional research design to examine the relationship between the siting of a GW in terms of active transit (AT) potential and GW users’ total GW-related PA. This study deliberately chose two GWs in Knoxville, TN due to their varying AT potential (high vs. low). The primary purpose was to study how comparable users of the low and high AT potential GW were and how their GW-related PA differed. Therefore a survey of adults was administered during the fall of 2010 which measured GW-related PA and user characteristics.

Subjects

Adults (over 18 years of age) using one of two greenways in Knoxville, Tennessee were recruited for this study. Data collected from infrared trail counters placed on each GW were used to anticipate the number of GW users throughout the day. Previous validation of the trail counter found that 95% of users are accurately counted. Miscounts resulted from side-by-side users (i.e., 2 or more trail users walking, jogging, or cycling past the trail counter at the same time), resulting in the infrared beam only being broken once. Walkers, joggers, and cyclists passing in a single file manner were captured by the trail counter regardless of the activity. Table 1 displays the average number of people utilizing each GW during three heavily used time periods from September to November 2009, the same months that were targeted for data collection in this study. From this table investigators anticipated that approximately 960 people would be using the GW during the data collection periods of this study with Lakeshore GW
having more 2.5 times the number of users than Third Creek GW. A decrease in trail counts from September to November can also be seen, reflecting a decrease in potential subjects over the course of the study.

Table 1: Mean 2009 Friday & Saturday GW Trail Counts by Month & Time

<table>
<thead>
<tr>
<th></th>
<th>Lakeshore</th>
<th>Third Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>September</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>93.7 ± 17.4</td>
<td>32.2 ± 16.4</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>72.2 ± 53.6</td>
<td>40.5 ± 33.5</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>68.8 ± 56.7</td>
<td>41.0 ± 23.2</td>
</tr>
<tr>
<td><strong>October</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>57.6 ± 26.6</td>
<td>15.7 ± 6.4</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>82.2 ± 57.5</td>
<td>26.4 ± 12.9</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>75.1 ± 47.7</td>
<td>29.3 ± 14.6</td>
</tr>
<tr>
<td><strong>November</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>91.4 ± 49.8</td>
<td>23.0 ± 12.9</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>89.6 ± 48.8</td>
<td>40.3 ± 19.5</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>60.5 ± 33.8</td>
<td>22.0 ± 11.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>691.1 ± 136.7</td>
<td>270.4 ± 55.0</td>
</tr>
</tbody>
</table>

Study Location

Two unique GWs in the Knoxville area were selected for inclusion in this study based on the potential (high vs. low) to access these GWs using active transit (AT). Third Creek GW (GW\textsubscript{high}) had high-AT potential as a result of being sited in a linear fashion that allowed multiple access and destination points within proximity to mixed-land use areas. Lakeshore GW (GW\textsubscript{low}) had low-AT potential by being sited in a circular fashion within an area separated from residential areas by fences, with only two access points on heavily traveled roads. Table 2 reflects the
varying accessibility of each GW. From this table it can be seen that compared to GW_{low}, GW_{high} had greater accessibility as defined by measures of proximity and street connectivity.

Table 2: Active Transit Accessibility Indicators by Greenway

<table>
<thead>
<tr>
<th></th>
<th>GW_{high}^a</th>
<th>GW_{low}^b</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proximity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population Density^c</td>
<td>2588.3</td>
<td>2238.5</td>
</tr>
<tr>
<td><strong>Street Connectivity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Intersections</td>
<td>41.0</td>
<td>54.0</td>
</tr>
<tr>
<td>Intersection Density^d</td>
<td>27.7</td>
<td>25.9</td>
</tr>
<tr>
<td>Link-Node Ratio^e</td>
<td>2.1</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>Road Type</strong>^f</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Roads</td>
<td>80.2%</td>
<td>90.2%</td>
</tr>
<tr>
<td>Primary Roads</td>
<td>6.4%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Secondary Roads</td>
<td>0.6%</td>
<td>9.8%</td>
</tr>
<tr>
<td>Highway Ramp</td>
<td>2.8%</td>
<td>0.0%</td>
</tr>
<tr>
<td><strong>Complete Streets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speed Limit</td>
<td>30.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Daily Traffic Counts^g</td>
<td>7978.5 ± 3733.6</td>
<td>14137.3 ± 4701.2</td>
</tr>
<tr>
<td># of Bus Stops</td>
<td>10.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Data taken from corresponding 2000 Census Tract for Knoxville, TN;
^aCensus Tract 37; ^bCensus Tract 44.01;
^cPopulation density: persons per square mile within Census Tract
^dIntersection Density: number of intersections per square mile within Census Tract
^eLink-Node ratio, number of links divided by the number of nodes
^fLocal Roads, neighborhood, city, or rural road with a single lane of traffic in each direction; Primary Roads, divided, limited-access highways distinguished by the presence of interchanges; Secondary Roads, main arteries that have one or more lanes of traffic in each direction; Highway Ramp, road allowing controlled access from adjacent roads onto a highway
^gDaily Traffic Counts, mean & SD.

Third Creek GW is a continuous GW 4.5 miles in length connecting to three other GWs in the Knoxville area [12]. The GW is located in commercial and residential areas and has several destination points or trip generators along its path (Figure 1).

Figure 1: Third Creek GW Map [12]
Lakeshore GW was established in 1996 and is a discontinuous loop GW 2.25 miles in length (Figure 2). It is surrounded by a fence and can be accessed by one of two heavily traveled roads [13]. Destinational points are non-existent as the GW is surrounded by residential areas. Both trails are paved, with access points located near parking areas.

Study Protocol

In order to address the research questions of this investigation a GW intercept survey was utilized (Appendix A). A 24-item, modified GW intercept survey was developed using the South Carolina Urban Rail-Trail Intercept Survey [55] and Indiana Clear Creek Survey [69]. The survey took approximately 6 minutes to complete and was designed to collect information about physical activity behaviors of GW leisure time and transportational PA among GW users. The GW survey was administered by two methods: an onsite intercept survey and an online survey.

The onsite intercept survey was conducted between September to November, 2010 at Lakeshore (GW\textsubscript{low}) and Third Creek (GW\textsubscript{high}) GWs on the first Friday and Saturday of each month, in order to reflect weekday and weekend GW use. The survey was conducted during
three heavily used time periods (see Table 1) on each GW throughout the study day and included the first two hours of daylight, 11:00 am – 1:00 pm, and the last two hours of daylight. If inclement weather occurred during the survey administration period, the survey was postponed and conducted the following Friday and/or Saturday.

The GW intercept survey was administered by trained interviewers, positioned next to an established trail counter on both GWs. In order to recruit participants, signs were posted to be visible to users in both directions approximately 0.25 miles and 25 meters away from the interview location on both GWs. Signs were used to inform users of the GW survey and promote user participation by describing the incentive for participation, a chance to win a free pair of running or walking shoes. As GW users passed the interview location they were approached by the interviewers using a recruitment and consent script for the Knoxville Greenway Survey (Appendix B). The purpose of the survey questionnaire was explained to each GW user prior to the start of the survey and respondent’s agreement to participate constituted consent.

The second manner by which data was collected for this study, an online survey, was utilized in an attempt to capture trail users who may not have had time to stop and complete the onsite intercept survey. This online survey was identical to the onsite interview survey. The questionnaire was created using SPSS MR Dimensionet software [70] and was hosted on a secure server through The University of Tennessee’s Office of Informational Technology. GW users indicating they could not stop and participate were invited by interviewers to participate in the online survey and were given a card with a link to the survey website. Users were directed to copy the survey link into the address bar of the internet software and once on the survey site, potential participants were instructed to read through the introductory information (Appendix C)
and signify their consent by advancing to a follow-up screen. After completing the survey, which took approximately six minutes to complete, participants were thanked for their time. Online participants were also offered the same incentive as onsite survey participants and were also informed that a valid email address was necessary to be eligible for the drawing.

**Study Measures**

This section discusses the dependent and independent measures of this study. One primary dependent factor, total GW PA, and a variety of independent factors were utilized in this study. The primary independent measure was GW AT potential. All other independent measures were treated as controlling measures.

**Dependent Measure**

Two PA related measures, GW-only and total GW-related PA, were the dependent variables in this study. Five questions were used to capture respondents GW-only and total GW-related PA over the past week: frequency of GW use in the past week, PA mode (e.g. walk, run, or bike) specific to each bout of PA, duration of PA bout, access mode (e.g. car, walk, run, or bike) to reach the GW, and travel time to access the GW from home. Taking the number of times PA was performed on the GW over the past week provided a frequency value. Intensity was identified using the *Compendium of Physical Activity* [71] to assign the appropriate Metabolic Equivalent (MET) for all PA bouts and access modes: 1.0 for car, 3.3 for walking, 4.0 for cycling, and 6.0 for jogging [71]. Taking the duration (minutes per bout) and intensity of the activity performed on the GW each day; MET minutes (MET·min) were calculated for each day and then summed to produce the GW-only PA measure in “MET·min·wk⁻¹.”

The calculation of total GW-related PA was similar to that of GW-only PA. Taking the reported time to access the GW and intensity of access mode; MET minutes (MET·min) were
calculated for each day and then summed to produce MET·min·wk\(^{-1}\) related to access of the GW. The accumulated MET·min·wk\(^{-1}\) attributed to GW access mode were then added to the GW-only MET·min·wk\(^{-1}\) to produce the total GW-related PA measure. The aforementioned measures were also categorized to determine the proportion of GW users meeting the 2008 Physical Activity Guidelines for Americans [1 = Low PA (<500 MET·min·wk\(^{-1}\)), 2 = Medium PA (500 – 1000 MET·min·wk\(^{-1}\)), 3 = High PA (> 1000 MET·min·wk\(^{-1}\))].

*Independent Measures*

**Demographic Measures:** Eight independent variables, all demographic, were used in this study. The demographic survey questions were derived from the Behavioral Risk Factor Surveillance System (BRFSS) [72] and included questions specific to age, gender, race/ethnicity, education, marital status, income, and employment status. Age was self-reported by GW users in years. Gender was categorized and coded into two groups: 1 = males and 2 = females.

Race/ethnicity was initially measured using two questions: “Are you Hispanic or Latino?” and “which one or more of the following would you say is your race?” Hispanic or Latino status was measured by a Yes/No question and race was categorized into six groups: White, Black or African American, Asian, Native Hawaiian or Other Pacific Islander, American Indian or Alaska Native, and Other. Due to the limited number of Hispanic/Latino and minority users, race/ethnicity was collapsed into two categories: 1 = Non-Hispanic, White, and 2 = Hispanic/Latino and Minority status.

Education was measured using seven potential responses: never attended school or only attended kindergarten, grades 1 – 8 (Elementary), grades 9 – 11 (some high school), Grade 12 or GED (high school graduate), college 1 – 3 years, college 4 years or more (college graduate), or
refused. These groups were then coded three categories: 1 = ≤ high school degree, 2 = college 1 – 3 years, and 3 = ≥ 4 years of college.

Marital status was measured using seven responses: married, divorced, widowed, separated, never married, a member of an unmarried couple, and refused. These responses were then collapsed to form three coded groups: 1 = living with a partner, 2 = previously married, 3 = single. The “married” category included users who indicated that they were married or a member of an unmarried couple. The “previously married” category included users who had been divorced, widowed, or separated. The “single” category represented those users who indicated they had never been married.

Income was measured using a question that asked users to classify their annual income into one of 10 groups: users making < $10,000, < $15,000, < $20,000, < $25,000, < $35,000, < $50,000, < $75,000, > $75,000, do not know, or refused to answer. These groups were collapsed into four categories: 1 = < $25,000, 2 = $25,000 – $49,999, 3 = $50,000 – $74,999, and 4 = > $75,000.

Employment status was measured using a question asking users to define their employment status using one of nine potential responses: employed for wages, self-employed, out of work for more than one year, out of work for less than one year, homemaker, student, retired, unable to work, and refused. These responses were then categorized and coded into four groups: 1 = employed, 2 = student, 3 = retired, and 4 = other. The “employed” category included users indicating they were employed for wages or self-employed. The “student” category included users who indicated they were out of work for more/less than one year, a homemaker, or unable to work. The “student” and “retired” categories were unchanged from the initial question responses.
**Proximity to GW:** The distance users live from the GW was also calculated by asking subjects to provide the nearest major intersection to their home by reporting the major street and cross street. Using Geographic Information Systems (GIS) [73], the reported intersections were geocoded and plotted on a map of Knox County, Tennessee. Using the roads layer, a network dataset was created and used to calculate the street network distance, in miles, from the reported intersections to the GW.

**Study-Related Measures:** Three study related measures included in analysis were month, years of GW use, and GW-AT potential. Month was used to control for seasonal variation in survey administration periods. Years of GW use was measured using 7 different responses: first use, less than 1 month ago, 1 to 3 months ago, 7 to 11 months ago, 1 – 3 years ago, and more than 3 years ago. These responses were then categorized and coded into three groups: 1 = less than 1 year, 2 = 1 – 3 years, 3 = over 3 years. In addition, GW-AT potential was used to contrast the volume of GW-related PA accumulated by users on both third creek (high-AT potential) and lakeshore (low-AT potential). Users on third creek GW (high-AT potential) received a code of 1 due to the high-AT potential of the GW. Lakeshore GW users received a code of 2 due to the low-AT potential.

**Statistical Analysis**

In order to address the research questions of this study, several statistical approaches were utilized. Initially, for continuous measures, descriptive statistics were conducted in order to determine normality of the data. Geographic Information Science (GIS) [73] was used to determine the street network distance users lived from the GW. For parametric measures, T-tests were conducted to determine if there were significant differences in the means of continuous survey measures (i.e. duration and frequency of PA and distance users live from the GW) and
GW AT potential. For non-parametric continuous measures, Wilcoxon Signed-Rank test was performed to determine if significant differences in medians existed. For these measures, the median and interquartile range was reported. Chi square was performed to determine if a significant difference existed between categorical survey measures (i.e. domain and mode of PA) and GW AT potential. Multiple regression was conducted to determine the relationship between GW user PA behaviors and characteristics; and GW AT potential. Due to the nonparametric nature of both dependent variables, log transformed MET·min·wk$^{-1}$ were used in the regression model. In a follow-up analysis using high AT users, logistic regression was conducted to determine a typical profile of GW users electing to access the GW via AT. Covariates in both the multiple and logistic regression models included study design components and demographic variables. As well, categorical variables in these models were dichotomized due to low sample size in various categories. Statistical analyses were conducted using PASW 19.0 software [74] with significance set at $p \leq 0.05$. 


CHAPTER 4

Manuscript

Abstract

Greenways (GW) can be sited to increase the potential for individuals to access the GW through active transit (AT) and provide opportunities for individuals to meet PA guidelines. PURPOSE: To determine if GWs, with varying AT access potential, relate to user characteristics and their GW-related PA. METHODS: A trail intercept survey measuring access mode, GW-specific PA, and demographics of GW users was administered to 611 adults on 2 GWs with high and low AT potential (GW_{high} vs. GW_{low}). RESULTS: Users of GW_{high}(N=216) compared to GW_{low} (N=400) were more likely to be younger, male, never married, employed, and affluent; accessing the GW via AT modes and accumulating greater volumes of GW-only and total GW-related PA (GW-only & AT PA). No difference in the proportion GW users meeting the 2008 PA Guidelines from GW-only PA was found however, 10.5% more users of GW_{high} met the guidelines from total GW-related PA compared to GW_{low} (p=0.039). Users who accessed GW_{high} by AT rather than cars were more likely to be not married (OR=2.6, 95% CI: 1.1 – 6.3), under 35 years old (OR=6.0, 95% CI: 1.9 – 19.26), live a mile from the GW (OR=5.39, 95% CI: 2.3 – 14.3). CONCLUSION: The profile of GW user and the way PA is acquired is related to the AT accessibility of GWs. Although PA levels of GW_{high} users were significantly higher, GW_{low} usage was greater. Therefore, GW planners and designers should incorporate universal design concepts and conduct needs based assessments to properly site and design GWs to serve the greatest portion of the population.
Introduction

Over recent decades, rates of sedentary lifestyles have risen to epidemic proportions [1, 2]. Many researchers and public health officials believe that a key in combating the epidemic of physical inactivity is to change the built environment (BE) in which individuals live to promote physical activity (PA) [3-5]. As early as 2002, legislative and policy makers recognized the need for increased access to places to perform PA within the BE. As a result, documents such as The Community Guide, Healthy People 2020, and the 2010 National Physical Activity Plan include objectives that recognize the need for communities to increase PA opportunities for individuals in the BE by enhancing access through environmental and policy interventions [6-8]. Specific recommendations included within these documents include tactics to enhance traffic safety in PA areas, encourage “complete street” and “livable community” policies and design, and increase connectivity and accessibility to community destinations [6-8]. These recommendations are ultimately thought to increase both transportational and leisure-time PA.

Greenways (GW) present one way to meet the PA recommendations; providing individuals, neighborhoods, and communities with opportunities to engage in outdoor leisure-time and transportational PA [9]. Ideally, GWs are sited near population centers and places for commercial land use in a manner to create “mixed land-use” environments that provide opportunities to run errands, shop, etc.; in addition to leisure-time PA [10]. An example of this type of GW can be seen in the Third Creek GW in Knoxville, Tennessee which is located in a well-established area of mixed land use. The GW provides multiple destination points along its path including neighborhoods, businesses, schools, and other public facilities [11, 12]. The siting of this GW within the BE also provides users the opportunity to access the GW via active transit (AT) to perform either leisure time or transportational PA. GWs can also be sited,
perhaps not deliberately, in manners that minimize access of individuals to the GW through active transit (AT). One example of this type of low-AT access GW can also be found in Knoxville, TN. Lakeshore GW is a stand-alone GW that is not integrated into the surrounding residential land-use and is distant from commercial land use parcels [13]. Lakeshore GW is also surrounded by a fence and borders two heavily trafficked roads that lack sidewalks or crosswalks. Individuals who live close to a GW may therefore have to take passive forms of transportation, like automobiles, to access the GW.

Currently, Knoxville, TN has constructed 36 GWs that total 41.9 miles in length [11]. These GWs were designed in either a linear, loop, or mixed linear-loop fashion and sited in either residential, commercial, or mixed commercial-residential land use. In a review of the 2009 GW master plan, it was found that 50% of constructed GWs in Knoxville are circular, 44.5% are linear, and 5.5% are mixed linear-loop in nature. In terms of GW siting, 36.1% of GWs were located in residential areas, 13.9% in commercial areas, and 50% in mixed commercial-residential land use areas [11]; reflecting high and low opportunities to access through AT. To date, no studies have been done to compare the siting of the GWs in relationship to user characteristics and their PA behaviors. Therefore, the purpose of this study was to determine if two GWs, with varying potential of AT access (high vs. low), relate to user characteristics and their PA behaviors. Two GWs that were hypothesized to have high and low AT potential were selected for this investigation. One GW mirrored the 2010 National Physical Activity Plan as it was based upon a foundation of a livable community and strived to meet complete street standards; allowing high potential to access via AT modes. In comparison, the second GW chosen for this study had low potential for individuals to access via AT due to barriers surrounding the GW such as high volumes of traffic and streets that lacked sidewalks.
and crosswalks. It was hypothesized that GW accessibility would be related to how users accessed the GW with users of the high-accessible GW compared to the low-accessible GW more likely to access the GW via AT modes.

**Methods**

**Study Design and Sample**

This cross-sectional study analyzed data from a trail intercept survey administered to adults using one of two GWs in Knoxville, TN during the fall of 2010. GWs were selected for inclusion in this study based on the potential (high vs. low) for individuals to access the GW using active transit (AT). Third Creek GW (GW\textsubscript{high}) had high-AT potential as a result of being sited in a linear fashion that allowed multiple access and destination points within proximity to zoned mixed-land use areas [12]. Lakeshore GW (GW\textsubscript{low}) had low-AT potential by being sited in a circular fashion within an area separated from residential areas by fences, with only two access points on heavily trafficked roads [13]. In addition, Lakeshore GW was far removed from commercial land use. Table 2 reflects the varying accessibility characteristics of each GW. From this table it can be seen that compared to GW\textsubscript{low}, GW\textsubscript{high} had greater accessibility as defined by measures of proximity, street connectivity, and street completeness in the Census Tract [75, 76] where the GW was located [5, 21, 24, 27, 61-66].
Table 2: Active Transit Accessibility Indicators by Greenway

<table>
<thead>
<tr>
<th></th>
<th>GW_{\text{high}} &amp; GW_{\text{low}}</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Proximity</strong></td>
<td></td>
</tr>
<tr>
<td>Population Density(^c)</td>
<td>2588.3</td>
</tr>
<tr>
<td><strong>Street Connectivity</strong></td>
<td></td>
</tr>
<tr>
<td># of Intersections</td>
<td>41.0</td>
</tr>
<tr>
<td>Intersection Density(^d)</td>
<td>27.7</td>
</tr>
<tr>
<td>Link-Node Ratio(^e)</td>
<td>2.1</td>
</tr>
<tr>
<td><strong>Road Type(^f)</strong></td>
<td></td>
</tr>
<tr>
<td>Local Roads</td>
<td>80.2%</td>
</tr>
<tr>
<td>Primary Roads</td>
<td>6.4%</td>
</tr>
<tr>
<td>Secondary Roads</td>
<td>10.6%</td>
</tr>
<tr>
<td>Highway Ramp</td>
<td>2.8%</td>
</tr>
<tr>
<td><strong>Complete Streets</strong></td>
<td></td>
</tr>
<tr>
<td>Speed Limit</td>
<td>30.0</td>
</tr>
<tr>
<td>Daily Traffic Counts(^g)</td>
<td>7978.5 ± 3733.6</td>
</tr>
<tr>
<td># of Bus Stops</td>
<td>10.0</td>
</tr>
</tbody>
</table>

\(^a\) Data taken from corresponding 2000 Census Tract for Knoxville, TN; \(^b\) Census Tract 37; \(^c\) Census Tract 44.01; \(^d\) Population density: persons per square mile within Census Tract; \(^e\) Intersection Density: number of intersections per square mile within Census Tract; \(^f\) Link-Node ratio, number of links divided by the number of nodes; \(^g\) Local Roads, neighborhood, city, or rural road with a single lane of traffic in each direction; Primary Roads, divided, limited-access highways distinguished by the presence of interchanges; Secondary Roads, main arteries that have one or more lanes of traffic in each direction; Highway Ramp, road allowing controlled access from adjacent roads onto a highway; \(^h\) Daily Traffic Counts, mean & SD.

Survey Procedures

The IRB committee at the University of Tennessee approved all study procedures. A modified trail intercept survey was developed using the South Carolina Urban Rail-Trail Intercept Survey [55] and the Indiana Clear Creek Survey [69]. The onsite intercept survey was conducted between September and November, 2010 at both at one key central location on both GWs on the first Friday and Saturday of each month, in order to reflect weekday and weekend GW use. The survey was administered during three heavily used time periods on each GW throughout the day and included the first two hours of daylight, 11:00 am – 1:00 pm, and the last two hours of daylight. Table 1 highlights the number of potential eligible study participants.
based on data collected in 2009 from infrared trail counters located on each GW. Assuming this level of GW use was maintained, we estimated seeing approximately 691 people on Lakeshore GW (GW\textsubscript{low}) and 270 on GW\textsubscript{high}, over a 2:1 ratio.

**Table 1:** Mean 2009 Friday & Saturday GW Trail Counts by Month & Time

<table>
<thead>
<tr>
<th></th>
<th>Lakeshore</th>
<th>Third Creek</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>September</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>93.7 ± 17.4</td>
<td>32.2 ± 16.4</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>72.2 ± 53.6</td>
<td>40.5 ± 33.5</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>68.8 ± 56.7</td>
<td>41.0 ± 23.2</td>
</tr>
<tr>
<td><strong>October</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>57.6 ± 26.6</td>
<td>15.7 ± 6.4</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>82.2 ± 57.5</td>
<td>26.4 ± 12.9</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>75.1 ± 47.7</td>
<td>29.3 ± 14.6</td>
</tr>
<tr>
<td><strong>November</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 – 9 am</td>
<td>91.4 ± 49.8</td>
<td>23.0 ± 12.9</td>
</tr>
<tr>
<td>11 – 1pm</td>
<td>89.6 ± 48.8</td>
<td>40.3 ± 19.5</td>
</tr>
<tr>
<td>5 – 7 pm</td>
<td>60.5 ± 33.8</td>
<td>22.0 ± 11.2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>691.1 ± 136.7</td>
<td>270.4 ± 55.0</td>
</tr>
</tbody>
</table>

During each selected period, trained interviewers approached GW users as they passed the interview location using a recruitment and consent script. Signs were also posted in both directions from the GW interview location to inform users of the survey and describe the participation incentive: a chance to win a free pair of running or walking shoes. Users agreeing to participate were explained the purpose of the study and verbal consent was obtained. For GW users indicating they could not stop and participate, a card with a link to an online version of the survey was given. Potential participants accessing the online survey were instructed to read through the introductory information and signify their consent by advancing to a follow-up screen. The time to complete both the onsite and online surveys was approximately 6 minutes.
Over the course of the study 1,115 people were engaged with trained interviewers. Of those who were approached, 45.2% completed either the face-to-face or online version of the survey which resulted in a final sample of 616 respondents ($GW_{high} = 216$, $GW_{low} = 400$) (Table 8).

**Measurement of Dependent Variables**

Two PA related measures, GW-only and total GW-related PA, were the dependent variables in this study. Five questions were used to capture respondents GW-only and total GW-related PA over the past week: frequency of GW use in the past week, PA mode (e.g. walk, run, or bike) specific to each bout of PA, duration of PA bout, access mode (e.g. car, walk, run, or bike) to reach the GW, and travel time to access the GW from home. Taking the number of times PA was performed on the GW over the past week provided a frequency value. Intensity was identified using the *Compendium of Physical Activity* [71] to assign the appropriate Metabolic Equivalent (MET) for all PA bouts and access modes: 1.0 for car, 3.3 for walking, 4.0 for cycling, and 6.0 for jogging [71]. Taking the duration (minutes per bout) and intensity of the activity performed on the GW each day; MET minutes (MET · min) were calculated for each day and then summed to produce the GW-only PA measure in “MET·min·wk$^{-1}$.”

The calculation of total GW-related PA was similar to that of GW-only PA. Taking the reported time to access the GW and intensity of access mode; MET minutes (MET·min) were calculated for each day and then summed to produce MET·min·wk$^{-1}$ related to access of the GW. The accumulated MET·min·wk$^{-1}$ attributed to GW access mode were then added to the GW-only MET·min·wk$^{-1}$ to produce the total GW-related PA measure. The aforementioned measures were also categorized to determine the proportion of GW users meeting the 2008 *Physical Activity Guidelines for Americans* [1 = Low PA (<500 MET·min·wk$^{-1}$), 2 = Medium PA (500 – 1000 MET·min·wk$^{-1}$), 3 = High PA (>1000 MET·min·wk$^{-1}$)] [34].
Measurement of Independent Variables

Eight demographic variables were utilized in this study. The demographic survey questions were derived from the Behavioral Risk Factor Surveillance System (BRFSS) [72] and included questions specific to age, gender, race/ethnicity, education, marital status, annual income, and employment status. Due to the low sample size of minority groups, all minorities were grouped together. Another independent measure, proximity to the GW, was measured using a question that asked subjects to pinpoint the nearest major intersection to their home. Using ArcMap [73], the reported intersections were geocoded and a network dataset was used to calculate the street network distance, in miles, from the reported intersections to the GW.

Three study related measures included in analysis were month, years of GW use, and GW-AT potential. Month was used to control for seasonal variation in survey administration periods. Years of GW use was measured using a question that asked subjects to classify their use of the GW. In addition, GW-AT potential was used to contrast the volume of GW-related PA accumulated by users on both third creek (high-AT potential) and lakeshore (low-AT potential). Users on third creek GW (high-AT potential) received a code of 1 due to the high-AT potential of the GW. Lakeshore GW users received a code of 2 due to the low-AT potential.

Statistical Analysis

In order to address the research questions of this study, several statistical approaches were utilized. Initially, for continuous measures, descriptive statistics were conducted in order to determine normality of the data. Geographic Information Science (GIS) [73] was used to determine the street network distance users lived from the GW. For parametric measures, T-tests were conducted to determine if there were significant differences in the means of continuous
survey measures (i.e. duration and frequency of PA and distance users live from the GW) and GW AT potential. For non-parametric continuous measures, Wilcoxon Signed-Rank test was performed to determine if significant differences in medians existed. For these measures, the median and inter-quartile range was reported. Chi square was performed to determine if a significant difference existed between categorical survey measures (i.e. domain and mode of PA) and GW AT potential. Multiple regression was conducted to determine the relationship between GW user PA behaviors and characteristics; and GW AT potential. Due to the nonparametric nature of both dependent variables, log transformed MET·min·wk$^{-1}$ were used in the regression model. In a follow-up analysis using high AT users only, logistic regression was conducted to determine a typical profile of GW users electing to access the GW via AT. Covariates in both the multiple and logistic regression models included month, years of GW use, and demographic variables. As well, categorical variables in these models were dichotomized due to low sample size in various categories. Statistical analyses were conducted using PASW 19.0 software [74] with significance set at $p \leq 0.05$.

**Results**

As hypothesized, access of the GW via AT modes was significantly greater at GW$_{\text{high}}$ compared to GW$_{\text{low}}$ ($37.0\%$ vs. $4.2\%$, $\chi^2 (4, 616) = 128.7, p < 0.001$) (Figure 3). Table 3 indicates that compared to GW$_{\text{low}}$, users of GW$_{\text{high}}$ were more likely to be younger ($44.0 \pm 13.6$ vs. $48.4 \pm 14.4, p < 0.001$), male ($60.7\%$ vs. $43.6\%, p < 0.001$), and never married ($29.8\%$ vs. $18.7\%, p < 0.006$). As seen in Table 4, No significant difference in the distance user’s lived from the GW was seen between GWs ($3.9 \pm 3.4$ vs. $3.5 \pm 2.9, p = 0.164$). The only difference in proximity was noted for those who drove cars with users who accessed GW$_{\text{high}}$ by car living significantly further from the GW compared to users of GW$_{\text{low}}$ ($4.6$ vs. $3.5$ miles, $p = 0.012$).
Frequency of weekly GW use was lower for GW\textsubscript{high} compared to GW\textsubscript{low} (2.6 ±1.8 vs. 3.2 ±1.9 days/wk, p < 0.001). However, users of GW\textsubscript{high} were more likely to engage in vigorous PA (34.7 vs. 22.0%, p < 0.001) with a greater duration of GW-related PA bouts (60 vs. 45 minutes, p < 0.001). Therefore, for both GW-specific PA measures in this study, GW\textsubscript{high} users accumulated significantly more MET-min·wk\textsuperscript{-1} than GW\textsubscript{low} users (p=0.012) (Table 4).

![Figure 3: Reported Access Mode of GW Users (p ≤ 0.001)](image-url)
Table 3: Demographic Profile of Users by Greenway

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>GW_high</th>
<th>GW_low</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years (x ± SD)</td>
<td>609</td>
<td>44.0 ± 13.6</td>
<td>48.4 ± 14.4</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>597</td>
<td>60.7%</td>
<td>34.8%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>616</td>
<td>95.8%</td>
<td>95.0%</td>
<td>p = 0.402</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>386</td>
<td>56.7%</td>
<td>67.7%</td>
<td>p &lt; 0.006</td>
</tr>
<tr>
<td>Previously Married</td>
<td>82</td>
<td>13.5%</td>
<td>13.6%</td>
<td></td>
</tr>
<tr>
<td>Single</td>
<td>137</td>
<td>29.8%</td>
<td>18.7%</td>
<td></td>
</tr>
<tr>
<td><strong>Education Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ HS Degree</td>
<td>32</td>
<td>5.1%</td>
<td>5.4%</td>
<td>p = 0.975</td>
</tr>
<tr>
<td>1-3 yr College</td>
<td>96</td>
<td>16.2%</td>
<td>15.6%</td>
<td></td>
</tr>
<tr>
<td>4+ yr College</td>
<td>478</td>
<td>78.7%</td>
<td>79.0%</td>
<td></td>
</tr>
<tr>
<td><strong>Employment Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>420</td>
<td>78.3%</td>
<td>64.1%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Student</td>
<td>46</td>
<td>10.8%</td>
<td>5.8%</td>
<td></td>
</tr>
<tr>
<td>Retired</td>
<td>65</td>
<td>2.8%</td>
<td>14.9%</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>77</td>
<td>8.0%</td>
<td>15.2%</td>
<td></td>
</tr>
<tr>
<td><strong>Annual Income</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; $25K</td>
<td>88</td>
<td>22.1%</td>
<td>13.2%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>$25 – 50K</td>
<td>110</td>
<td>23.6%</td>
<td>18.9%</td>
<td></td>
</tr>
<tr>
<td>$50 – 75K</td>
<td>94</td>
<td>20.1%</td>
<td>16.2%</td>
<td></td>
</tr>
<tr>
<td>&gt; $75K</td>
<td>240</td>
<td>34.2%</td>
<td>51.7%</td>
<td></td>
</tr>
</tbody>
</table>

*Age reported as mean and Standard Deviation;
*Categorical measures reported as proportions determined by Chi Square
* Married: currently married or living with a partner; Previously Married: separated, divorced, or widowed; Other: unemployed, homemaker, or unable to work
Table 4: GW-specific PA behaviors of Users by Greenway

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>GW&lt;sub&gt;high&lt;/sub&gt;</th>
<th>GW&lt;sub&gt;low&lt;/sub&gt;</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Years of GW Use</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 yr</td>
<td>78</td>
<td>18.5%</td>
<td>9.5%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>1 – 3 yr</td>
<td>107</td>
<td>24.1%</td>
<td>13.8%</td>
<td></td>
</tr>
<tr>
<td>3 + yr</td>
<td>430</td>
<td>57.4%</td>
<td>76.7%</td>
<td></td>
</tr>
<tr>
<td><strong>PA Domain</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leisure-Time</td>
<td>592</td>
<td>89.4%</td>
<td>99.7%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Transportation</td>
<td>24</td>
<td>10.6%</td>
<td>0.3%</td>
<td></td>
</tr>
<tr>
<td><strong>Access Time to GW</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car</td>
<td>517</td>
<td>13.6 ± 8.4</td>
<td>9.2 ± 6.5</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>AT modes&lt;sup&gt;c&lt;/sup&gt;</td>
<td>96</td>
<td>11.4 ± 9.5</td>
<td>14.7 ± 15.9</td>
<td></td>
</tr>
<tr>
<td><strong>Proximity to Home (miles)</strong>&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Modes</td>
<td>532</td>
<td>3.9 ± 3.4</td>
<td>3.5 ± 2.9</td>
<td>p = 0.164</td>
</tr>
<tr>
<td>Car Only</td>
<td>454</td>
<td>4.6 ± 3.6</td>
<td>3.5 ± 2.9</td>
<td>p = 0.005</td>
</tr>
<tr>
<td>AT Modes&lt;sup&gt;c&lt;/sup&gt;</td>
<td>78</td>
<td>2.9 ± 2.7</td>
<td>3.8 ± 3.8</td>
<td>p = 0.414</td>
</tr>
<tr>
<td><strong>PA Mode on GW</strong>&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking</td>
<td>364</td>
<td>24.1%</td>
<td>78.0%</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Running</td>
<td>163</td>
<td>34.7%</td>
<td>22.0%</td>
<td></td>
</tr>
<tr>
<td>Biking</td>
<td>89</td>
<td>41.2%</td>
<td>0.0%</td>
<td></td>
</tr>
<tr>
<td><strong>GW PA Frequency</strong>&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days/week</td>
<td>616</td>
<td>2.6 ± 1.81</td>
<td>3.2 ± 1.93</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td><strong>GW PA Duration</strong>&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min/Bout</td>
<td>609</td>
<td>60 (45 – 90)</td>
<td>45 (40 – 60)</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td><strong>PA Volume (MET·min·wk&lt;sup&gt;-1&lt;/sup&gt;)</strong>&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GW-only&lt;sup&gt;e&lt;/sup&gt;</td>
<td>608</td>
<td>630</td>
<td>569</td>
<td>p = 0.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(396 – 1050)</td>
<td>(297 – 990)</td>
<td></td>
</tr>
<tr>
<td>Total GW-related&lt;sup&gt;f&lt;/sup&gt;</td>
<td>609</td>
<td>720</td>
<td>614</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(440 - 1200)</td>
<td>(320 - 1070)</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Variables reported as the proportion of GW users  
<sup>b</sup> Variables reported as means and standard deviations  
<sup>c</sup> Active transit modes including walking, jogging, or bicycling  
<sup>d</sup> Variables reported as medians & (interquartile range)  
<sup>e</sup> Physical activity performed solely on the greenway  
<sup>f</sup> Combined greenway and active transit physical activity

The association between GW access potential and GW-specific PA was further explored with multiple regression. In the regression model, 5.0% and 5.9% of the variance in GW-only
and total GW-related PA were explained after controlling for month, demographics, and GW accessibility. GW-specific PA volumes were significantly greater in users who were younger, had an annual income greater than $50,000, and were users of the highly accessible GW (GW_{high}). After controlling for all variables, GW accessibility was positively associated with increases in the volume of GW-specific PA accumulated by GW users (Table 5).

Table 5: Predicted GW and GW & AT-related PA of Users

<table>
<thead>
<tr>
<th>Variable</th>
<th>GW-Only PA</th>
<th>Total GW-related PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>6.912**</td>
<td>0.620</td>
</tr>
<tr>
<td>Gender</td>
<td>0.126</td>
<td>0.089</td>
</tr>
<tr>
<td>Age</td>
<td>-0.008*</td>
<td>0.003</td>
</tr>
<tr>
<td>Race</td>
<td>0.317</td>
<td>0.232</td>
</tr>
<tr>
<td>Marital Status</td>
<td>0.048</td>
<td>0.094</td>
</tr>
<tr>
<td>Education Level</td>
<td>-0.092</td>
<td>0.106</td>
</tr>
<tr>
<td>Annual Income</td>
<td>0.230*</td>
<td>0.099</td>
</tr>
<tr>
<td>Employment Status</td>
<td>0.170</td>
<td>0.091</td>
</tr>
<tr>
<td>Proximity to Home</td>
<td>-0.28</td>
<td>0.034</td>
</tr>
<tr>
<td>Month</td>
<td>-0.085</td>
<td>0.056</td>
</tr>
<tr>
<td>Years of GW Use</td>
<td>0.079</td>
<td>0.094</td>
</tr>
<tr>
<td>GW Accessibility (high vs. low)</td>
<td>0.196*</td>
<td>0.092</td>
</tr>
</tbody>
</table>

Dependent Variables: Log Transformed PA, MET·min·wk^{-1}
*Referent categories are: September, less than 3 years of GW use, female, white, married/living with a partner, < college degree, < $50,000, employed, live >1 mile away from GW, low-AT GW; age modeled as a continuous variable
$R^2 = 5.0\%$ & $5.9\%$ for GW-only PA and Total GW-related PA, respectively.
*p < 0.05; **p < 0.001

When looking at the GW-specific PA volume of GW users in relation to the 2008 PA Guidelines (Figure 4), there was no difference in the proportion of users meeting these guidelines from GW-related PA (p=0.33). However, when AT-related PA was taken into account, the
The proportion of users meeting the 2008 PA Guidelines was 10.5% greater for GW\textsubscript{high} compared to GW\textsubscript{low} (p \leq 0.05).

**Figure 4:** Proportion of GW Users Meeting the 2008 PA Guidelines (MET\(\cdot\)min\(\cdot\)wk\(^{-1}\))

Due to the lack of AT access of users on GW\textsubscript{low} (Table 4), a more specific analysis was conducted on GW\textsubscript{high} users only to determine how the mode used to access the GW related to both GW-only and total GW-related PA. Results of this analysis indicate 4.9% and 9.1% of the variance in GW-only and total GW-related PA on GW\textsubscript{high} were explained by month, demographics, and access mode (Table 6). A significant association between volume of GW-specific PA and the mode used to access the GW was found with a trend toward increased volume of GW-specific PA when users accessed the GW via AT modes (Table 6).

**Table 6:** Model Predicting GW-Specific PA Among Users of the Highly Accessible Greenway (GW\textsubscript{high}) Only
When looking at the access mode of users on GW\textsubscript{high} a significant difference in the profile of users was seen. Specifically, users who chose to access GW\textsubscript{high} by AT modes (\textit{i.e.}, walk, jog, or bike) were more likely to be not married (OR = 2.63; 95\% CI = 1.10 – 6.30), under the age 35 (OR = 6.00; 95\% CI = 1.87 – 19.16), and live within one mile of the GW (OR = 5.39; 95\% CI = 2.03 – 14.30) (Table 7).

<table>
<thead>
<tr>
<th>Variable</th>
<th>GW-Only PA</th>
<th>Total GW-related PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>5.595**</td>
<td>1.089</td>
</tr>
<tr>
<td>Gender</td>
<td>0.128</td>
<td>0.147</td>
</tr>
<tr>
<td>Age</td>
<td>- 0.007*</td>
<td>0.006</td>
</tr>
<tr>
<td>Race</td>
<td>0.509</td>
<td>0.398</td>
</tr>
<tr>
<td>Marital Status</td>
<td>- 0.030</td>
<td>0.156</td>
</tr>
<tr>
<td>Education Level</td>
<td>0.096</td>
<td>0.190</td>
</tr>
<tr>
<td>Annual Income</td>
<td>0.182*</td>
<td>0.175</td>
</tr>
<tr>
<td>Employment Status</td>
<td>0.090</td>
<td>0.173</td>
</tr>
<tr>
<td>Proximity to Home</td>
<td>- 0.014</td>
<td>0.056</td>
</tr>
<tr>
<td>Month</td>
<td>- 0.049</td>
<td>0.090</td>
</tr>
<tr>
<td>Years of GW Use</td>
<td>0.139</td>
<td>0.146</td>
</tr>
<tr>
<td>GW Access Mode (Car vs. AT)</td>
<td>0.151*</td>
<td>0.149</td>
</tr>
</tbody>
</table>

Dependent Variable: Log Transformed PA, MET-min-wk\textsuperscript{-1}

*Referent categories are: September, less than 3 years of GW use, female, white, married/living with a partner, < college degree, < $50K employed, live >1 mile away from GW, access mode: car; age modeled as a continuous variable

R\textsuperscript{2} = 4.9\% & 9.1\% for GW-only PA and Total GW-related PA, respectively.

*p < 0.05; **p < 0.001
Table 7: Profile of Users Electing to Use Active Transit on the Highly Accessible Greenway (GW\textsubscript{high}): Results of Binary Logistic Regression

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>OR</th>
<th>95% C.I.</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>58</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>97</td>
<td>1.67</td>
<td>0.74, 3.71</td>
<td>p = 0.215</td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>150</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Minority</td>
<td>5</td>
<td>6.24</td>
<td>0.62, 62.67</td>
<td>p = 0.120</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>87</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Not Married</td>
<td>68</td>
<td>2.63</td>
<td>1.10, 6.30</td>
<td>p = 0.030</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Some College or lower</td>
<td>28</td>
<td>1.00</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>College degree or higher</td>
<td>127</td>
<td>1.09</td>
<td>0.42, 2.85</td>
<td>p = 0.867</td>
</tr>
<tr>
<td>Annual Income</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under $50,000</td>
<td>70</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Over $50,000</td>
<td>85</td>
<td>1.58</td>
<td>0.60, 4.12</td>
<td>p = 0.354</td>
</tr>
<tr>
<td>Employment Status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employed</td>
<td>117</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Not Employed</td>
<td>38</td>
<td>1.09</td>
<td>0.42, 2.85</td>
<td>p = 0.857</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 35</td>
<td>54</td>
<td>6.00</td>
<td>1.87, 19.16</td>
<td>p = 0.027</td>
</tr>
<tr>
<td>35 – 44</td>
<td>26</td>
<td>3.47</td>
<td>0.93, 12.93</td>
<td></td>
</tr>
<tr>
<td>45 – 54</td>
<td>36</td>
<td>3.13</td>
<td>0.91, 10.78</td>
<td>p = 0.070</td>
</tr>
<tr>
<td>&gt; 55</td>
<td>39</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Distance via Road Network</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 mile</td>
<td>37</td>
<td>5.39</td>
<td>2.03, 14.30</td>
<td>p = 0.004</td>
</tr>
<tr>
<td>1 – 1.99 miles</td>
<td>28</td>
<td>0.69</td>
<td>0.25, 1.93</td>
<td></td>
</tr>
<tr>
<td>2 – 2.99 miles</td>
<td>11</td>
<td>1.24</td>
<td>0.30, 5.16</td>
<td></td>
</tr>
<tr>
<td>&gt; 3 miles</td>
<td>79</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Month</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td>82</td>
<td>---</td>
<td>---</td>
<td>p = 0.828</td>
</tr>
<tr>
<td>October</td>
<td>45</td>
<td>1.17</td>
<td>0.47, 2.90</td>
<td></td>
</tr>
<tr>
<td>November</td>
<td>28</td>
<td>0.81</td>
<td>0.30, 2.22</td>
<td></td>
</tr>
<tr>
<td>Years of Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 3 years</td>
<td>67</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>&gt; 3 years</td>
<td>88</td>
<td>1.20</td>
<td>0.55, 2.66</td>
<td>p = 0.654</td>
</tr>
</tbody>
</table>
Discussion

Results of this investigation, the first to draw a comparison of two GWs at both ends of the accessibility continuum, indicate GW user profiles and related PA behaviors vary by accessibility created by GW siting and design. As hypothesized, GW accessibility was related to how users accessed the GW with users of the high-accessible compared to the low-accessible GW being less likely to rely on a car. The highly accessible GW compared to the low-accessible GW was also more likely to be used by younger, male, not married, employed, and less affluent individuals. Except the income status of the users, the profile of the high-accessible GW users is consistent with previous GW research [9, 10, 22, 27, 49-51, 56-59].

In terms of proximity, the distance users traveled to access the GW was not significantly different between GWs. Traditionally proximity has been used to describe where GW users live while investigating the probability that individuals in the general population will use the GW. Results from our study are comparable, indicating that users live within close proximity of the GW [10, 22, 23, 50, 52]. However, when accounting for the user’s mode of access, users of the low-accessible GW that accessed by car lived approximately one mile closer to the GW than the high-accessible GW users. These results may be explained by lower levels of accessibility in areas surrounding the low-accessible GW. Specifically, barriers created by lower street connectivity as well as greater volumes and speeds of vehicles prevented many users of the low-accessible GW from accessing the GW through AT modes [4, 21, 23].

No significant differences in the proportion of users meeting the 2008 Physical Activity Guidelines from GW-related PA behaviors was found between the high and low accessible GWs. However, the PA behaviors of these users was significantly different with users of the low accessible GW visiting the GW more frequently during the week and more likely to walk while
on the GW (78.0%) compared to those of the highly accessible GW (24.1%). The greater percentage of walkers on the low-accessible GW PA is related to two demographic factors: being female and older. Previous research indicates that females and older adults are more likely to engage lower intensity PA compared to their younger, male counterparts [77, 78].

Users of the highly accessible GW were also found to spend more time on the GW per visit while also performing higher intensity PA (i.e. jogging or bicycling), compared to users of the low-accessible GW. The additional PA acquired by traveling to the GW and engaging in longer, more intense PA bouts allowed users of the high-accessible GW to accumulate significantly more GW-only and total GW-related PA than users of the low accessible GW. These results are consistent with studies investigating the relationship between land-use mixture, an indicator of accessibility, and GW use which indicate that overall GW usage tends to be higher in areas of commercial land use [10, 22, 24, 27].

When AT-related PA was taken into account, significant differences in the proportion of users meeting guidelines was found with 10.5% more users meeting the guidelines on the high-accessible GW compared to users of the low-accessible GW. To date, this is the first GW study to use the 2008 PA Guidelines to quantify the PA levels of GW users, especially as it relates to active transit. Access of the highly accessible GW through AT modes was also related to a user profile of individuals who were more likely to be affluent, younger, male, and living in close proximity of the GW. In terms of proximity, high-accessible GW users living within 1 mile of the GW were 5 times more likely to access the GW via AT modes.

Results from this study indicate there are many factors that GW designers and planners should consider when deciding where to site a GW. Specific to siting and designing GWs, the present study suggests that the ability to access a GW through AT should be considered, as it
enables individuals to use the GW for both transportational and leisure-time PA purposes. Therefore, highly accessible GWs provide a way for communities to meet Healthy People 2020 objectives to increase leisure-time and transportational PA. In addition, the increased AT on highly accessible GWs has the potential to positively impact several environmental health goals such as reduced automobile traffic and fuel consumption. Assuming the average car gets 22.1 miles per gallon users on the highly accessible GW who access via AT modes reduce their fuel consumption by 35.48 gallons of gas per year which equates into a savings of $125.25 per person [79].

Conversely, low accessible GWs also have several benefits that should be considered by GW planners and designers. Most importantly is that GWs designed in a low-accessible manner might have high levels of use, despite their barriers for individuals to access through AT. The users of these low-accessible GW appear to be more purposeful in how they acquire PA. For example, our study found users of the low-accessible GW used the GW for a greater number of years while visiting the GW more frequently during the week. Thus, low accessible GWs may have greater reach when the goal is to increase PA at the community level. It is important to note that due to access barriers inherent within a low-accessible GW, individuals living in close proximity to the GW may lose the opportunity to acquire PA through AT as they travel to the GW. The lost opportunity for additional PA on low-accessible GWs creates another factor that city planners should consider: providing adequate parking for users driving to the GW.

It is important to note there are several limitations of this study. First, regression analysis indicates only 5% of the variance in GW-related and total GW and AT-related PA can be explained by survey design measures, demographics, and GW-AT potential. The low variance explained by the variables in this investigation may be attributed to the sampling design.
Specifically, studies found to explained a greater proportion of the variance in GW-related PA have included a control group comprised of non-GW users [21-23, 52, 53]. Another limitation in our study is that the GIS measures used to describe GW accessibility were limited and that proximity was measured by self-report. Therefore, we believe future studies should measure accessibility on a broader scale using a more robust GIS analysis and/or environmental accessibility audits in order to determine the relationship between GW AT potential and GW-related PA.

Several other limitations exist that should be considered when interpreting the results of this investigation. Due to the cross-sectional design of this study, causal inferences related to the association between GW-AT potential and GW-related PA cannot be made. The use of a convenience sample and an incentive may have also influenced who participated in the survey, thus introducing selection bias in our results. Also, self-reported survey data were used in this study to measure GW-specific PA behaviors. Although this method is commonly used in GW research [9, 21-23, 26, 51-53, 55-60], there is a potential for recall bias, especially when asking users to report the duration of PA bouts on the GW. Therefore, future studies should consider incorporating objective measures of PA using pedometers, accelerometers, or GPS devices mounted to bikes, in order to provide a better estimate of GW-related PA.

Despite the aforementioned limitations, the present study has several strengths inherent in its design. The large sample size and accompanying statistical power of 80.2% allowed researchers to conduct a robust analysis. In addition, administering surveys at the same time each month on both GWs allowed researchers to control for potential temporal and weather-related confounders between GWs. Furthermore, the use of both an on-site and online survey
format enabled researchers to capture the profile and PA behaviors GW users who may have not had time to complete the on-site survey.

Results of this study indicate the ability to access GWs through AT modes is important in effectively siting and designing GWs that allow communities to create additional opportunities for individuals to accumulate outdoor PA. In particular, increased accessibility may be important to increase active transit PA, resulting in greater volumes of PA that can ensure individuals are more likely to meet public health PA guidelines. However, low accessible GWs should also be considered when siting and designing GWs as they may have the potential to reach a greater percentage of the surrounding community. Therefore, needs based assessments that incorporate Census Tract data and GIS mapping should be used to determine the best GW design for a particular site [80]. In addition, universal design concepts that provide functional and aesthetic components targeting various needs of the population should be used to serve the greatest number of individuals within the community where the GW is located [81]. While this is the first study to contrast varying levels of GW accessibility, many more studies with a broader scope should be conducted to further understand this relationship. Further research is also necessary to better understand PA behaviors and motivations of GW users within the context of perceived AT accessibility as it relates to GW use.
LIST OF REFERENCES


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APPENDICES
Appendix A

Knoxville Greenway Intercept Survey

For Official Use Only:
Interviewer Initials: ______
Subject ID: ___
Date: _______
Survey Time: _______ (am/pm)
Activity Type: ___ Walking ___ Jogging or Running ___ Bicycling ___ Other (please specify): _____________
Person’s Sex: ___ Male ___ Female

Interviewer Says: To start off, I’d like to ask you questions having to do with your use of the greenway today and over the last 7 days.

1. What is your purpose for using the greenway today? (Interviewer: Read Choices Below)
   ___ Recreation/Leisure time activities
   ___ Commuting from work or school
   ___ Running Errands

2. Over the past week, how many days did you use the greenway? _______ days

<table>
<thead>
<tr>
<th>Domain</th>
<th>Mode</th>
<th>Minutes</th>
<th>Bouts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Tuesday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Wednesday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Thursday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Friday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Saturday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
<tr>
<td>Sunday</td>
<td>LTPA</td>
<td>W J B O</td>
<td></td>
</tr>
</tbody>
</table>

Interviewer: Fill in chart

6. How much time does it usually take you to get to the greenway system from your home? ________ minutes

7. What time of day do you prefer to use the greenway?
   ___ Early Morning (5am-9am)
   ___ Mid-Morning (9:01 am-12pm)
   ___ Early Afternoon (12:01-3pm)
   ___ Late Afternoon (3:01-6pm)
   ___ Evening (6:01-9pm)
8. Where did you start your current greenway activity from today? *(Interviewer: Read choices below)*
   ____ Home
   ____ Work
   ____ Retail stores, businesses or places like the library or church
   ____ Parking Lot
   ____ Other (please specify):__________________________

9. How do you usually access this greenway? *(Interviewer: Read choices below)*
   ____ Car or motorcycle
   ____ Walk
   ____ Jog or Run
   ____ Bicycle
   ____ KAT
   ____ Other (specify) ______________________

10. Can you recall the first time you used the greenway?
    ____ Today
    ____ Less than 1 month ago
    ____ 1 to 3 months ago
    ____ 4 to 6 months ago
    ____ 7 to 11 months ago
    ____ 1 – 3 years ago
    ____ More than 3 years ago

    *(Interviewer Says: We are also interested in your perceptions of the weather and how it relates to your use of the greenway)*

11. Have hot temperatures ever kept you from using the greenway?
    ____ No
    ____ Yes  If yes…What temperature in degrees Fahrenheit would be too hot for you to use the greenway? ______

12. Have cold temperatures ever kept you from using the greenway?
    ____ No
    ____ Yes  If yes…What temperature in degrees Fahrenheit would be too cold for you to use the greenway? ______

13. Has rain or snow ever kept you from using the greenway?
    ____ No
    ____ Yes  If yes…What amount of rain or snow would prevent you from using the greenway? *(Read Choices)*
    ____ Very Light Rain or Snow (sprinkling)
71

___ Light Rain or Snow (drizzling)
___ Steady Rain or Snow

14. Has wind ever kept you from using the greenway?
   ___ No
   ___ Yes  If yes…What amount of wind would prevent you from using the greenway?
            _______ (mph)

The map below shows areas on and around the greenway

15. What direction did you approach the greenway from today? (North, South, East, West)

Third Creek Map

Lakeshore Greenway
Interviewer Says: We are also trying to determine how far away people who use the greenway live. Would you be willing to provide the nearest intersection located near your home?

Major Street _________________________ Cross Street _________________________

Interviewer Says: This last set of questions have to do with demographic information which will help us understand who uses the greenway. This information will not be used to identify you.

18. What is your age?
   _____ (years) _____ Refused/do not wish to answer

19. Are you Hispanic or Latino?
   ___ Yes ___ No

20. Which one or more of the following would you say is your race?
   (Interviewer: Read Choices/Check all that apply)
   ___ White ___ Native Hawaiian or Pacific Islander
   ___ Black or African American ___ American Indian or Alaska Native
   ___ Asian ___ Other (specify) __________________

21. What is your marital status?
   ___ Married ___ Never married
   ___ Divorced ___ A member of an unmarried couple
   ___ Widowed ___ Refused
   ___ Separated

22. How would you define your employment status?
   ___ Employed for wages ___ Student
   ___ Self-employed ___ Retired
   ___ Out of work for more than 1 year ___ Unable to work
   ___ Out of work for less than 1 year ___ Refused
   ___ Homemaker

23. What is the highest grade or year of school you completed?
   ___ Never attended school or only attended kindergarten
   ___ College 1 to 3 years
   ___ Grades 1 through 8 (Elementary)
   ___ College 4 years or more (College graduate)
   ___ Grades 9 through 11 (Some High School)
   ___ Grade 12 or GED (High School Graduate)
   ___ Refused
24. What is your annual income?
   ___ Less than $10,000   ___ Less than $35,000
   ___ Less than $15,000   ___ Less than $50,000
   ___ Less than $20,000   ___ Less than $75,000
   ___ Less than $25,000   ___ Refused

*Interviewer Says: Thank you for your participation in the survey. Would you like to participate in our drawing for a $50 gift certificate to Runners Market?*

*If the respondent answers yes:*
   If you could, please provide your email address on the following sheet for us to contact you if you win.

*If the respondent answers no:*
   Thank them again for their time

**** Offer all survey respondents a sheet with study and contact information****
Appendix B

Recruitment & Consent Script for Knoxville Greenway Intercept Survey

Background for the Intercept Survey Script
The greenway intercept survey will be administered at two different greenways in Knoxville, TN on the first Monday and Saturday of the month. The survey will be conducted in three, two hour time increments with the study spanning over four months from September to December, 2010. The following script will be used by trained interviewers to recruit participants for the greenway intercept survey.

The Interviewer approaches the greenway user and says: Hi- I am a researcher from the University of Tennessee and we’re conducting a research study on the use of greenways in Knoxville. Would you be willing to spare 10 minutes to complete survey on your use of this greenway?

If person indicates they do not have time to complete the survey the interviewer will say: Would you be willing to complete an online survey on your use of the greenway?

If the person says yes the interviewer will hand the user a card with a link to the survey

   If person declines the interviewer will say: Thank you anyway, Enjoy your day.

If trail user looks like they are in their twenties or younger, say: The study we are conducting is limited to people 18 and older. Are you 18 or older?

If the person says no: Thank the person for their time and don’t proceed with survey.

If the person says yes proceed with survey, the interviewer will say:
Before we start, I want to inform you about your rights as a research subject:
  • Your responses to this survey are confidential
  • Your participation is voluntary. You can stop the survey at any time and you can skip questions you do not want to answer, however, it is important that you try to answer every question as accurately and truthfully as possible.
  • There are no consequences of refusing to participate

The interviewer will then ask: Does this sound okay to you?

If person declines: Thank you anyway. Enjoy your time on the greenway
If the person accepts, continue with survey
The interviewer will have fact sheets available for survey respondents with the study and UTK IRB contact information printed on them. After conducting the survey, the interviewer will offer the respondent a fact sheet in case he/she has questions about their rights as a research participant study or later has questions regarding the research.
Appendix C

Online Greenway Survey Consent Form

Thank you for taking a few moments to complete this survey. The survey should take approximately 10 minutes for you to complete. Your responses to this survey are confidential, and the information provided will be used for research purposes only. Participation in this survey is voluntary and there are no consequences for refusing to participate. You can stop the survey at any time and you can skip questions you do not want to answer, however, it is important that you try to answer every question as accurately and truthfully as possible. At the end of the survey, you will be asked if you wish to be entered in the drawing for a free pair of running or walking shoes. If you indicate you would like to be entered in the drawing, you will be directed to a different site to register, so that your survey responses remain anonymous and are not linked to personal information provided for the drawing. If you agree to participate in this survey please continue by pressing the next button.
### Table D-1: Knoxville Greenway Onsite and Online Survey Response Rate by GW & Month

<table>
<thead>
<tr>
<th>Greenway</th>
<th>In-Person Surveys</th>
<th>Refusals</th>
<th>Repeats</th>
<th>Asked to Complete Online Survey</th>
<th>Online Surveys Completed</th>
<th>Online Response Rate&lt;sup&gt;1&lt;/sup&gt;</th>
<th>Overall Response Rate&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>September</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>80</td>
<td>0</td>
<td>122</td>
<td>26</td>
<td>21.30%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LS</td>
<td>131</td>
<td>0</td>
<td>173</td>
<td>47</td>
<td>27.17%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>October</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>47</td>
<td>23</td>
<td>142</td>
<td>24</td>
<td>16.90%</td>
<td>33.49%</td>
<td>40.50%</td>
</tr>
<tr>
<td>LS</td>
<td>123</td>
<td>59</td>
<td>61</td>
<td>31</td>
<td>22.62%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>November</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>31</td>
<td>21</td>
<td>12</td>
<td>8</td>
<td>66.67%</td>
<td>58.33%</td>
<td></td>
</tr>
<tr>
<td>LS</td>
<td>44</td>
<td>15</td>
<td>30</td>
<td>21</td>
<td>28.00%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>459</td>
<td>82</td>
<td>574</td>
<td>157</td>
<td>30.44%</td>
<td>45.21%</td>
<td></td>
</tr>
</tbody>
</table>

<sup>*TC- Third Creek, LS- Lakeshore, In-Person Surveys – surveys completed in person on greenway, Refusals – users approached to participate but declined, Asked to Complete Online Survey – users given online survey card</sup>

<sup>1 Online Response Rate: (Online Surveys Completed) / (Asked to Complete Online Surveys)</sup>

<sup>2 Overall Response Rate: (Face-to-Face Surveys + Online Surveys Completed) / (Face-to-Face Surveys + Refusals + Asked to complete online survey)</sup>
Table D-2: Demographic measures comparing surveyed GW users and the population surrounding each GW based on the 2000 U.S. Census Data

<table>
<thead>
<tr>
<th></th>
<th>GW_{linear} Users</th>
<th>Population</th>
<th>GW_{circular} Users</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median Age (years)</strong></td>
<td>45.0</td>
<td>30.1</td>
<td>50.0</td>
<td>41.4</td>
</tr>
<tr>
<td><strong>Male</strong></td>
<td>60.7%</td>
<td>49.7%</td>
<td>34.8%</td>
<td>48.1%</td>
</tr>
<tr>
<td><strong>Non-Hispanic White</strong></td>
<td>95.8%</td>
<td>82.8%</td>
<td>95.0%</td>
<td>96.1%</td>
</tr>
<tr>
<td><strong>Marital Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>56.7%</td>
<td>36.2%</td>
<td>67.7%</td>
<td>62.0%</td>
</tr>
<tr>
<td>Previously Married</td>
<td>13.5%</td>
<td>21.3%</td>
<td>13.6%</td>
<td>18.3</td>
</tr>
<tr>
<td>Single</td>
<td>29.8%</td>
<td>42.5%</td>
<td>18.7%</td>
<td>19.7%</td>
</tr>
<tr>
<td><strong>Education Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ HS Degree</td>
<td>5.1%</td>
<td>29.1%</td>
<td>5.4%</td>
<td>22.8%</td>
</tr>
<tr>
<td>1-3 yr College</td>
<td>16.2%</td>
<td>13.7%</td>
<td>15.6%</td>
<td>23.9%</td>
</tr>
<tr>
<td>4+ yr College</td>
<td>78.7%</td>
<td>57.2%</td>
<td>79.0%</td>
<td>53.3%</td>
</tr>
<tr>
<td><strong>Employed</strong></td>
<td>78.3%</td>
<td>62.1%</td>
<td>64.1%</td>
<td>67.2%</td>
</tr>
<tr>
<td><strong>Income Level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; $25K</td>
<td>22.1%</td>
<td>60.3%</td>
<td>13.2%</td>
<td>15.9%</td>
</tr>
<tr>
<td>$25 – 50K</td>
<td>23.6%</td>
<td>20.3%</td>
<td>18.9%</td>
<td>22.4%</td>
</tr>
<tr>
<td>$50 – 75K</td>
<td>20.1%</td>
<td>5.3%</td>
<td>16.2%</td>
<td>25.8%</td>
</tr>
<tr>
<td>&gt; $75K</td>
<td>34.2%</td>
<td>14.1%</td>
<td>51.7%</td>
<td>35.9%</td>
</tr>
</tbody>
</table>

*aUsers who completed the survey at each GW

*bPopulation of residents surrounding GW, taken from 2000 Census Tract [76]
VITA

Dana Lizbeth Wolff was born on March 28, 1987 in Mineola, New York. Shortly after her birth her parents moved to Chesapeake, Virginia where Dana lived throughout her childhood. In 2005 Dana graduated from Hickory High School and enrolled at Elon University where she obtained a Bachelor of Science degree in Exercise Science with concentrations in Statistics and Public Health in 2009. Throughout her Bachelor degree, Dana was a Lab Assistant at Elon including: Exercise Physiology, Human Anatomy, and Introduction to Biology. Immediately following completion of her Bachelor’s Dana enrolled at The University of Tennessee and accepted a position as a Graduate Teaching Associate where she taught Exercise Testing and Prescription lab, Weight Training, Conditioning and Walking. This research is part of the current pursuit of her Master’s Degree in Exercise Physiology with a concentration in Epidemiology. Dana has been accepted as a Doctoral candidate in Kinesiology at The University of Tennessee starting in the fall of 2011.