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Parks and Trail Hubs as Green Gyms

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Research on the influence of community, neighborhood, and park design on physical activity has gained interest in the 21ˢᵗ century. One dominant park amenity considered by urban planners and park designers are trails and trail hubs to a park system and regional trail network. Trail hubs act as an intersection where multiple trails converge and visitor's services such as parking, restrooms, water, or exercise areas are provided. Trail hubs are increasingly included in new park designs or in modifications of older parks to facilitate active transportation and active physical activity levels for better health conditions. Few studies have examined how specific park features across different parks influence physical activity levels. This study evaluates physical and social behaviors within and across parks to test the outcomes of park features. Park user data were collected in situ from 1,089 park users with a random sample approach over a three-month period. Data were collected on physical activities, purpose of park visit, social composition of users, and temporal variables at three urban parks of different aged neighborhoods in Singapore. Users were intercepted at two areas within each park -- a multi-use area and the dominant trail hub area. Results suggest that an overall park design, including its age and its park amenities, influences park uses. Self-reported physical activities and motives for park visitation showed that vigorous physical levels and exercise motives occurred at a high proportion at trail hub areas compared to general park facility areas. Solo users were more likely to be located in trail hub areas, whereas park users with families, children or friends were more likely to use general park facility areas. The newest of the three parks studied, which featured a trail hub that provides extensive access to trails and coastal area, particularly exhibited high levels of vigorous and moderate physical activity. The value of these findings is in helping park designers and planners better understand the outcomes of different neighborhood and park design layouts, through the allocated amenities within an area and in relation to the immediate surroundings of the park area. Trail hubs developed in new or existing trail or park systems were associated with greater physical activity levels. Future research could test trail hubs outside of park settings to determine if these findings transfer to additional community areas. With evidence of different behaviors in park settings, park planners can serve the exercise and social needs of urban dwellers.

INTRODUCTION

Today, urban environments are being refashioned with a host of new initiatives to achieve sustainability, resiliency, and livability. Ecosystem services found in cities include: conserving biodiversity (Andersson et al. 2007; Faeth et al. 2011) while providing opportunities for recreation and the generation of social capital (Chiesura 2004; Bedimo-Rung et al. 2005; Low et al. 2005), as well as for economic returns through tourism and higher property taxes (Nicholls and Crompton 2005). An urban environment is therefore like an experiment unto itself in trying new innovations and adopting or adapting innovations that add value to a complex human designed environment (Tan and Jim 2017). Some of the urban greening initiatives which aim to improve human and environmental conditions while achieving reliable economic returns include recreational trail networks and improving park access. Urban parks have been known to be a form of response to pressing urban problems, each generation with its own ideas of how parks can help cities (Cranz and Boland 2004). In the mid-1800s, during a time of 'moral degradation' due to intense urbanization, government-provided parks in America were implemented with the intention of protecting the health, safety and welfare of residents. Today, the fifth generation of urban parks – the Sustainable Park – exists within an integrated network which embrace a wider range of users and outcomes that align with urban sustainability efforts (Ackley 2014). A growing body of research illustrates the myriad of environmental and social benefits of parks. For example, greenspace and trees in parks (e.g., Kardan et al. 2015), human well-being and sustainability (Chiesura 2004; Ibes 2014), and the use of parks to improve public health (e.g., Bedimo-Rung et al. 2005; Cohen et al. 2007, 2016). Access to public parks and trails can help improve outcomes – physical, psychological, social, and ecosystem services – as identified by Schultz et al. (2016).

The research problem is to examine the relationship between design elements of parks with the social composition of park users and their physical activity levels. In other words, this research is positioned as an evaluation of the adaptation of trail hubs within parks as an influence on human behaviors. Trail hubs, as defined by trail practitioners and also in this study, is a design element of an intersection of multiple trails where facilities such as parking, restrooms, water, or exercise areas are provided. They are pieces of a larger trail network and are often the entrance points to parks. To judge the impact of trail hubs on human behaviors, this study examined trail hubs in several parks. Some of the hubs could have been added to existing parks while in other cases, a new park could be linked to an existing hub. Separate "non-trail hub" areas within each of the parks were also studied. As a proxy for physical activity and social context, the recreation activities of park users were studied. The purpose of the research is to provide user data to assist park managers and urban planners in better visualizing the effects of enhanced trail networks for recreation on higher levels of physical activity, in terms of both the proportion of people engaged or the intensity of the physical activity. Networks of green space and trails in park settings affords humans connectivity to public places and nature through greater community access with the development of trail hubs.

REVIEW OF LITERATURE

Researchers continue to pursue evidence of the human-ecology linkage. Parks, particularly those within urban environments, are important spaces to examine linkages. Chiesura (2004) studied the benefits of nature and parks close to home and found evidence of strong mental, physical and social

outcomes as a sign of a sustainable city. Recently, Lincoln et al. (2016) and Cohen et al. (2016) published research considered to be national in scope with evidence of parks contributing to well-being and recommended daily physical activity levels. Ackley (2014) drew attention to the "continual task of re-envisioning desirable forms and functions of individual greenspaces and parks….to modify these spaces for future needs (p 5)." This research draws on the nexus of previous research to evaluate the physical outcomes and social context of new park amenities and designs.

Parks and Trails

Recent studies are increasing the recognition of parks as a vital health resource toward increased physical activity that meet the levels recommended by the medical field or the government (Bedimo-Rung et al. 2005; Cohen et al. 2016). With Robert Wood Johnson Foundation's focus on the role of community design and its impact on health and physical activity, there has been a plethora of recent empirical studies using a wide variety of methods (Robert Wood Johnson Foundation 2013). Studies by park researchers stand out for their collection of primary data collected in parks covering a range of social, economic and environmental dimensions. These studies have shown that parks are used as spaces for people to seek restoration, spend time with friends and family (Kazmierczak 2013), and engage in physical activity (Floyd et al. 2008a, 2008b). Interdisciplinary teams of researchers, including park researchers, continue to examine the influence of the built environment in the form and function of residential living, transportation, retail, parks, and other community design elements on healthy living, obesity, and reduction of chronic diseases (Ding and Gebel 2012). Park and greenspace research claims that the social, mental health, environment and economic benefits (Bedimo-Rung et al. 2005) from nature exposure (Ackley 2014) can make even greater contributions to developing healthier and sustainable urban communities (Larson et al. 2016).

Trails have high potential to increase recreation through the provision of facilities for non-motorized transportation through a trail system, including both within a park's premise and those connecting different parks (Tan 2006; Meyers et al. 2012). Tan (2006) documented the evolution of Singapore's park connector system and described the nature of human use and appreciation. The system aimed to address many national goals, including optimizing the use of limited land space, while encouraging physical activity and health outcomes, and reducing social isolation. The planning and recreation literature has shown that many of the recommended vigorous (jogging, running, fast walking, cycling) or moderate (walking) physical activities are best done on trails which can accommodate longer distances (Cohen et al. 2016). Shore and West (2010) found that for urban parks, a trail-based park held the highest level of vigorous activity levels (81%) compared to a sports park (61%), neighborhood park (54%), or multi-purpose park (49%). Veitch et al. (2012) showed that a change in facilities (e.g. walking trails, dog play area) at an intervention park, as compared to a park without improvement, led to a significant increase in visits and activities that meet vigorous physical activity levels. These findings are consistent with previous research that found that the inclusion of trails at parks had the strongest association with physical activity (Kaczynski et al. 2008).

The effects of parks and trails on physical activity levels and social composition of users requires an understanding of their geographic, built, and social context (Low et al. 2005; Parés et

al. 2006; Ibes 2014; Ibes 2016; Lincoln et al. 2016). Research has demonstrated that parks are not functionally equivalent (Cohen et al. 2016), and its effects differ amongst a population with different preferences, backgrounds, and other constraints. Factors such as the environment (i.e., size of park, park features and amenities) and the socio-demographic profile (i.e., population density surrounding a park, diversity of residents) of its nearby residents and other users contribute to how the park is used. Rind and Jones (2011) claimed that the recreational physical activity could be partly explained by geographical features such as urban versus rural. They concluded that human behavior may best be understood along recreational opportunities provided within a geography and the demographic profiles of those who live near or travel to parks. Kaczynski et al. (2010) reported that parks where physical activity occurred were more likely to be located on land of low-density use or residential areas than high or mixed-use areas. Shore and West (2010) examined urban and rural parks which were categorized into neighborhood, multi-purpose, sports, and trail and found different levels of physical activity for each type. Floyd et al. (2008) reported different physical activity levels across two cities and related ethnic differences to facilities and recreation activities participated in. Cohen et al. (2016) found the level of programming and marketing to influence levels of park usage.

In a systematic review of the literature, Schultz et al. (2016) suggested 11 measures to examine health outcomes related to the built environment. These include the size of greenspace, percentage of green, availability/accessibility of parks and trails, proximity and walking time to parks and trails, distance buffers around parks and trails, population density, types of facility, types of amenities, condition of parks and trails, and incivilities. Only a few studies were found to specifically examine how a trail system influences park use in terms of physical activity levels and demographic characteristics of users. Broadly, empirical research suggests that specific amenities or features of parks influence physical activity levels and the social composition of park users (e.g., Shore and West 2010). The age of a park is also likely to influence the design features of the park and nearby area. While studies examining parks across different eras or styles of park designs are less common, urban areas generally consist a mix of older and newer parks.

Approaches to Study Parks and Trails

Recent studies on physical activity and park and trail use (Starnes et al. 2011) have gained interest in the topic's methodologies and its forms of measurement. Researchers from the fields of transportation, urban planning, health and exercise science, and parks have constructed and tested a wide range of methodologies primarily for observations, surveys, and new technologies. Many of these studies have created new instruments and tested reliability and validity using multi-method designs. McKenzie (2002) examined the use of observation to examine physical activity and was part of a team (McKenzie et al. 2006) that created the SOPARC instrument (System for observing play and recreation in communities) which has been widely used to render a national study (Cohen et al 2016). Floyd et al. (2008a, 2008b) applied the SOPARC instrument to a study of two different cities to test external validity of recording activities in several sections of parks. Brownson et al. (2004a) tested three questionnaires regarding social context for physical activity. Brownson et al. (2004b) also tested two audit instruments – one which was analytical in format and the other used a checklist format to study environmental factors. Spruijt-Metz et al. (2010) reported psychometric characteristics of the Research on Urban Trail Environments (ROUTES) Trail Use Questionnaire using test-retest to show reliability; validity was assessed by comparing reported trail use to self-

reported and objectively measured physical activity levels. Dunton et al. (2009) tested measures from accelerometers and compared these measures to surveys which collected data on user demographics, reason for trail use, and the type of physical activity on the trail. Troped et al. (2010) employed a combination of accelerometers and GPS data to obtain relatively objective measures of the built environment and its location-based physical activity to examine park and trail use.

Measurements of park and trail use have also incorporated non-questionnaire or human observation techniques, particularly with use counts as the primary measure. Lindsey and colleagues (2008) studied a large urban greenway system using transportation and planning technologies. They studied the influence of trail characteristics trail use through the application of remote sensing and geographic information systems. Another study (Lindsey et al. 2007) on the same greenway system used infrared monitors to estimate trail use. Ottensmann and Lindsey (2008) examined trail volume by the Hansen measure of accessibility, a measure which weighs the opportunities available in each zone according to the difficulty level of accessing it. They reported that accessibility to linear features, such as trail hubs and safe crossings, provided better predictions of trail use.

This study seeks to better understand the differences in human behaviors based on park design by comparing trail hubs to multi-purpose facilities areas. To isolate use and user differences, physical and environmental aspects of a park were matched as closely as possible. Based on the reviewed literature, two key outcomes of park and trail designs emerged– physical activity levels and social composition, however these outcomes have not been studied for different park design features. For physical activity, this research evaluates the extent trail hubs within parks *elevate* the proportion of vigorous physical activity in comparison to multi-purpose facilities. For social context, this research evaluates the extent trail hubs *differ in* terms of single or group park use in comparison to multi-purpose facilities. Empirical data from parks of different design eras, each with trail hubs and areas with multi-purpose facilities, provides compelling evidence to test trail hubs as a park design intervention, particularly at mature parks.

METHODOLOGY

Study Site

Singapore was selected to test the role of park age and facility design on physical activities and social park user composition because of the country's approach to urban development. The planning of land resource is by a national level agency, the Urban Redevelopment Authority (URA), which also oversees park land allocation. Parks are managed by another national level government agency (National Parks Board) ranging from those in smaller neighborhoods to larger nature reserves. This arrangement provides a stark contrast as park agencies in other countries often act as managers and tend to have different missions. Singapore's public agencies collaborate on the development and ongoing maintenance of built park resources, which is a considerably lean management approach. Over the country's 50 years of independence, Singapore's urban planning agency has developed and redeveloped entire neighborhoods, thus providing a unique opportunity to study how physical activity in different aged park-neighborhoods might vary.

Parks in Singapore are considered highly accessible and integrated into residential areas throughout the island of 718.3 square kilometers. Additionally, the development of the islandwide park trail, the Park Connector Network (PCN), extends active transportation and recreation opportunities across the island. Since its inception in 1991, over 300 km of trails have been completed. The distribution of parks has been targeted to be within 400m of housing for at least 90% of Singapore residents by Singapore's current Land Use Master Plan (Singapore Urban Redevelopment Authority 2014). The housing and park development policies allow the Singapore government large control over land use, therefore enabling active living to be promoted in a more equitable manner. One way this has been accomplished is through the public housing agency's (Housing Development Board 2014) planning and selling of apartment units, according to factors such as income level, to achieve socially equitable targets (Yuen 2010). In 2010, 83% of households lived in government built multi-story apartments, which are set in mixed use, high density developments. Private condominiums (11%) and houses (6%) comprise a lower proportion of household units (Department of Statistics 2011). Also, with a diverse ethnic population comprising mainly Chinese, Malays, Indians, and Eurasians, its local government has set in place integration policies and programs for housing and education in order to ensure a socially harmonious society. This was an important delimitation of the study, given the focus of this research on the influence of neighborhood and park design on park use.

Singapore's national policies and the inter-relationship amongst agencies provide an interesting case study (Ding and Gebel 2012) of a unique socio-cultural environment, which is also highly focused on ecological biodiversity (Tan 2006). With the PCN, over 25 large parks have been linked to provide an extended trail system for cyclists, runners, and walkers to enjoy parks and park-like settings along linear corridors. The build out of this system was challenging in older areas of the city, and easier in newer areas undergoing structural development. In addition to linking population centers and parks, PCNs were also seen as a viable way to create ecosystem links within the urban environment. As part of this initiative, PCNs had to be integrated into existing parks with older designs. To do so, the distance between two existing parks location of nearby estates were considered before a PCN was developed. In addition, plaza areas were strategically located along connectors to enhance its attractiveness for users. No research to date has examined the combination of a trail network and parks in Singapore, although Tan (2006) has published on Singapore's trail and greenway network and Yuen (2010) on local neighborhood parks.

Today, NParks oversees 381 parks of various sizes covering a total of 2,324 hectares, including regional parks (N=58), neighborhood parks (N=264), and PCN (N=59), across the city-state (National Parks Board 2013). Most urban parks and PCNs in Singapore are open 24 hours a day with night lighting from 7 pm to 7 am. Morning and evening use are popular use times given tropical temperatures ranging around 31 to 34°C (National Environment Agency 2015) throughout most of the year. A population of 58 regional parks was available for study. The goal was to select a set of parks to represent different eras of urban planning – mature, middle-aged, and young – following the classification used by Singapore's Housing Development Board to manage urban planning.

Site Selection

A regional park, often greater than ten hectares in size, serves a diversity of large-scale recreational opportunities and often attracts park users living beyond the neighbourhood. Singapore's trail network, a minimum of 6m wide, forms an integrated and seamless network through linking the park system. The parks and neighborhoods are considered mixed-use, dense neighborhoods and the parks in Singapore are generally perceived as safe (National Parks Board 2016).

To study the interaction of these urban features, several desirable characteristics for a social science study on park use were developed for selection of parks: (1) adjacent and nearby housing; (2) accessible with public transportation and parking lots available; (3) a primarily resident sample (rather than a tourist sample); and (4) at least two distinct areas of the park with developed features to study trail-connector use and multi-purpose park use. Importantly, each selected park needed to represent neighborhoods of different locational ages which represent planning eras. Using these criteria, a dozen parks from out of 58 regional parks were visited to select several possible parks for the different neighborhood age categories. The design of the study was focused on selecting three parks that matched on many physical and access features so to better control for those which have been found to influence park use (Shore and West 2010; Ibes 2016). Item 4 was particularly important in the study's design to test park design features as distinct places that would be associated with different levels of physical activities and social composition of park users. The parks selected included two parks where trail hubs were added to existing parks and one newer park where the trail hub and park were recently co-constructed. To allow for comparison, the three trail hub zones (as well as the three multi-purpose zones), were judged by park professionals assisting in the research to be similar enough in terms of their features. In the final selection, the three parks shared common features (had a distinct water feature, regional, housing density) and had distinct areas or zones with the desired features (i.e., trail hub, multi-purpose area) to test the influence of facilities on park use.

In statistical testing, each park was treated as a distinct place for analytical comparison of trail hubs (Zone A) and multi-purpose facilities (Zone B) as shown in Table 1. A trail hub or Park Connector (PCN) was identifiable as a gateway into the park from trails outside the park. Trail hubs had branded signage and maps of the PCN system, as well as benches and shelter that could be used by PCN trail users and general park users. The trail hubs studied were all located within the park, which enabled a study design that kept the neighborhood and park context the same and varied the zone amenities. Each park had multiple trail hubs to provide access through the park. Prior visits and observations conducted in these parks helped to better understand and identify the location of the dominant trail hub in the park, then selected as the survey site. Three parks were selected for this study to present each of the neighbourhood design types: mature, middle-aged, and young.

Mature Park in a Mature Neighborhood. The first selected park (Park #1), Bedok Reservoir, is located in a mature estate (Table 1) which early development plans started in 1963 (HDB 2014), around the time Singapore became its own nation state and when urban planning began. According to the latest census (Department of Statistics 2011), 423,000 adults or 164,815 households live in the two districts where the park is located. Housing is both public in the form of large apartment style complexes offered by the government, and private, with condominium complexes and a small

number of landed houses. The demographic profile of this neighborhood is older, comprising more singles or two adult households, and ethnically diverse (Chinese, Malay, Indian). The park size is 42 ha, with an additional 88 ha man-made lake in its center. Surrounded by a 4.3 km long trail, the park's dimension is 1.8 km in length and a width of 850 m. Park activities are primarily land based recreation, however, fishing is allowed in designated areas and anglers were included in the study. This park offers a mature tree canopy throughout. Few major renovations have occurred over the park's existence other than the addition of the trail hub in 2007.

Table 1. Park amenities by varying park ages and zones within a park

Park #1 – Mature		Park #2 – Middle-aged		Park #3 – Young	
Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
PCN[a] link	--[b]	PCN link	--	PCN link	--
Trails	Trails	Trails	Trails	Trails	Trails
Jetty on lake	Jetty on lake	Bridge over river	Bridge over river	Bridge over river	Bridge over river
Playground	Playground	Playground	Skate park	--	Splash playground
Fitness Corner	Fitness Corner	--	--	--	Fitness Corner
Toilet	--	--	Toilet	Toilet	Toilet
Parking lot	--	--	Parking lot	--	Parking lot
Restaurant	Adjacent to commercial area	--	Several restaurants	--	--
--	Bird singing corner	--	Dog park	--	--

[a] PCN is the Park Connector Network managed by National Parks Board of Singapore.

[b] Denotes the amenity was not in the zone.

Middle-Aged Park and Neighborhood. The second park (Park #2), Bishan-Ang Mo Kio, is located in a middle-aged estate and was built in the late 1980's to early 1990's. This park is 62 ha, 2.8 km in length and 400m at its widest part, with a road running through its middle. It is one of Singapore's largest parks and, like the park in the mature estate, has a mix of public and private housing condominiums adjacent to it, and landed houses nearby. About 213,000 adults or 87,162 households live in the two districts where the park is located. The demographic profile of this neighborhood is older, where single or two adult households are more common than families, and is ethnically diverse (Chinese, Malay, Indian). The park was developed along one of Singapore's rivers, which connects a central catchment of several reservoirs for water retention. The river is an important aesthetic feature to the park and was restored as a natural riverbank from a concrete drainage structure in 2012, which created a heightened interest in biodiversity at the park. This park is a multi-purpose or general park with a wide variety of amenities and restaurants within the park. Many parts of the park have a mature tree canopy, but along with the riverbank restoration, a new open space area was created after removing mature vegetation. Of the three parks studied, Bishan-Ang Mo Kio is a destination park that is made up of many attractions, including a fast food

restaurant, dog park and skate park. The first-generation Park Connector was added to Bishan-Ang Mo Kio Park in 1995 (Tan 2006).

New Park and Young Neighborhood. The third park (Park #3), Punggol Waterway, is located within a young-aged estate with an initial development date of 2007. Co-created with the HDB, the park was one of the earlier completed sites in the neighborhood and has been promoted as an amenity to attract new residents. The Punggol neighborhood primarily holds public housing apartments. The current population of the single district where the park is located is 42,070 adults and 18,043 households but these figures are constantly changing as new housing is completed in the area. The demographic profile of this neighborhood is relatively younger compared to the two other areas studied. The park is linear in shape (26 ha, 4.2 km in length by 62 m wide) and connects to other nearby trails, therefore offering a 26 km trail experience along the northern shoreline which is less built-up than other parts of the island. The main feature of the park is a trail on each side of the waterway, with occasional gazebos, benches, restrooms, a spray park and a fitness corner located in the middle part of the waterway. This new park attracts long distance cyclists, park visitors who want to explore a new place, and its nearby residents. The Park Connector to Punggol Waterway Park was added in 2012 (Ministry of National Development 2012).

Sampling Frame

Data were collected over a three-month period (April to June) in 2014. There is little seasonal variation throughout the year, given Singapore's geographical location near the equator. A random sampling frame was constructed around weekday (Monday to Thursday) and weekend (Friday to Sunday); and time periods (morning, afternoon, evening) to include 13 hours of daylight (7 am to 8 pm). Days and times were randomly assigned to a calendar of 91 possible days. All sampling days were implemented; and while it rained on a few days, data collection continued.

Two researchers worked together in two predetermined zones in each park. The "A" zone was the trail hub area of the park; and "B" zone was the multi-purpose area of the park. Two hours of surveys were conducted by each researcher at the same time within a zone. A single researcher conducted the surveys in a designated sub-zone. In an hour, 45 minutes was committed to surveying and 15 minutes to observation by each researcher. Researchers moved to the second zone after two hours. For each weekday or weekend day and time period, a zone A-B and a B-A sequence were implemented to minimize any time use bias. On each survey day for each zone, three hours of surveying were completed. A total of 12 sampling occasions were completed at each park for a total of 36 sampling occasions across the full study's sampling frame.

Altogether, 1,089 completed surveys were obtained (59% response rate). Two-dozen surveys (24 or 1%) were removed from the dataset because they were incomplete, not completed by someone 18 years or older, or by a nonresident. Refusals were also tallied (n=761, 40% refusal rate) and classified to assess under-representation in the sample. The proportion of refusals are proportionately in line with park user groups: men (69%) compared to women (31%); refusals from walkers (36%), runners (27%), cyclists (24%), or other users (13%); and the reasons expressed for refusing were: not willing (58%), language barrier (22%), no time (16%), or already surveyed (4%). A resident based sample was achieved with only five respondents indicating they resided outside the country.

Measures

The survey instrument was a one-page questionnaire including 18 questions and administered on a clipboard in the field. Every five minutes, a person in a user group, the unit of analysis, was randomly intercepted (Table 2). If a person refused, a second group was attempted within the five-minute frame. However, if no survey was completed during that period, it was not made up for in order to maintain a systematic random sample.

Table 2. Characteristics of measures

Items	Type of data and other notes
Unit of data collection and analysis	Randomly selected one respondent per park user group. Weighted any use variables into user data.
Activities	Nominal data turned into dummy variables. Multiple activities allowed for group. Eight activities recoded into vigorous, moderate and sedentary dummy variables.
Duration of current visit	Ratio data
Frequency of park use (visits per 30 days)	Ratio data. Used to weight use data.
Single purpose for park visit	Categorical data
Group composition	Nominal data. Types of social units.
Facility type	Park – trail; multi-purpose
Type of day, time, and place (park and zone within a park)	Ratio data recoded into categorical data.

Question formats were kept simple for the respondents and fieldwork administration; hence the questions yielded primarily nominal or categorical data. Most questions were framed for the current park visit, however, the experience history of park usage over the last 30 days was also asked. The number of park visits is an important data point to accurately estimate user characteristics. Without an adjustment to use or transaction estimates, those who use the park frequently have a higher likelihood of being sampled compared to someone who visits the park once. Therefore, a weighting factor was computed as 1/# of park visits in 30 days and applied to questions not specific to a particular park visit.

Schultz et al. (2016) categorized park and trail outcome measurements into five broad categories: physical, psychological, social, ecosystem services, and built environment. The measures in this study follow four of the five categories – physical, psychological, social and built environment. The study included all the self-reported physical measures outlined by Schultz et al. (2016): type of physical activities, duration of park visit, and frequency of park visit. Physical activity levels were measured with a list of eight self-reported activities for the user group that the park agency uses to monitor types of park uses (Table 3). A respondent would select all activities that his or her park user group was engaged in during the current park visit which may have included more than one type and different levels of physical activities. All the activities were dummy-coded into three levels: vigorous, moderate and sedentary following standards of the World Health Organization (2014). Duration of the current park visit was expressed in number of minutes (Table 2). Frequency of park visits was expressed as the number of park visits over 30 days. Purpose of the current park visit was self-reported with six options (exercise, relaxation,

socialize, park program, transit through the park, and others which was open-ended) and the composition of the park user group with seven options (spouse or girl/boyfriend, children or grandchildren, other family, neighbor or friend, work colleague, domestic help). Built environment characteristics were embedded in the design of the study to create two distinct zones for three parks of different ages. Two of the 11 measures outlined by Schultz et al. (2016) were dominant in the park and sampling area selection – type of facility and the availability of trails and greenways.

Table 3. Physical activities studied by level of physical activity

Levels of Physical Activity[a]	On-site Survey Items
Vigorous	Cycling
	Jogging/ Running
Moderate	Walking
	Walking dog
	Exercising/ Stretching/ Fitness Corner
	Playing on playground
Sedentary	Sitting/ Resting
	Eating – restaurant, barbeque, picnic

[a] Physical activities were classified into respective levels following the World Health Organization, Singapore Health Promotion Board, and U.S. Center for Disease standards.

Data Analysis

The design of this research was to select parks that would yield unique findings about physical activity levels and to test the influence of park amenities located in zones on activity levels and the social composition of users. In addition to behavioral measures, park visit purpose and temporal measures are used to provide a more robust profile of park use.

Park type and zone were treated as fixed variables across the analysis. Analyses were conducted using primarily non-parametric or two- and three-way nested measures of association analysis. The Cramer's V test of association was employed along with z-test to compare cell proportions or frequencies between zones with a Bonferroni adjusted p-level (Sirkin 1995). The V value is the inter-correlation of two discrete variables that could be used with nominal or ordinal data types (Liebetrau 1983). Two variables were collected in the survey as ratio data (length of current visit, experience use history with park) and differences between zones were tested using an independent t-test. For all tests, a p-level of less than 0.05 was used to determine significance across the analysis.

FINDINGS

Description of On-site Intercepted Trail Hub and Park Users

A demographic description of respondents of the on-site park survey is first provided by park and segmented by park zones (trail, multi-purpose). Across the three park sites, men exceeded women proportionately (Table 4). At all three parks, men were a larger proportion than women at trail hubs compared to multi-purpose areas. As for age range of park users, the middle-aged park skewed slightly older than the other two parks. Using postal codes, respondents were placed into one of three categories to measure distance from their homes to the park edge. The two older parks

had a higher proportion of users living adjacent the park. In contrast, the newest park had the largest proportion of its users from beyond the neighborhood district.

Table 4. Demographic profile of park users by park and zone

| | Park #1 – Mature | | Park #2 – Middle-aged | | Park #3 – Young | |
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Gender of respondent						
Male	68.1%	60.9%	65.9%	56.6%	66.8%	65.1%
Female	31.9	39.1	34.1	43.4	33.2	34.9
Age of respondent						
18-29 years	25.5%	20.4%	15.3%	23.6%	31.1%	17.9%
30-44 years	39.6	42.5	34.7	27.4	32.1	51.6
45-59 years	26.4	29.6	29.4	33.0	27.4	21.7
60 and above	8.5	7.5	20.6	16.0	9.5	8.7
Residential proximity from park						
Adjacent to park	26.8%	43.5%	34.6%	35.9%	7.7%	13.6%
Nearby park	49.1	42.9	44.2	30.3	21.0	23.7
Outside/ beyond the neighborhood district	24.1	13.7	21.2	33.8	71.3	62.7

Testing of the Contribution of Trail Hubs to Physical Activity Levels and Socialization Across Park Types

The survey instrument ascertained the single *purpose* of why respondents were at the park. As shown in Table 5, the trail hub area of the park (Zone A) was associated with higher levels of *exercise* at two of the three parks (Park #1 Zone A: 75% vs. Zone B: 63%, V=.14, p<.05; Park #3 Zone A: 76% vs Zone B: 60%, V=.17, p<.01) as compared to users intercepted in the park facility area (Zone B). For the same parks, *relaxation* as the single purpose for visiting a park was higher for Zone B compared to Zone A (Park #1 Zone B: 29% vs. Zone A: 19; Park #3: Zone B: 26% vs Zone A: 17). The third reason tested was *socializing,* which was the least popular purpose and similar across zone types.

Table 5. Single purpose[a] for park use by park and zone

| | Park #1 – Mature | | Park #2 – Middle-aged | | Park #3 – Young | |
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Exercise	75.0% A	62.5% B	68.6%	68.2%	75.6% A	60.2% B
Relax	19.3A	28.8B	21.2	24.5	17.2A	26.3B
Socialize	5.7	8.7	10.3	7.3	7.2	13.5
Statistic Test[b]	V=.14, p<.05		V=.06, ns		V=.17, p<.01	

[a] Other reasons were omitted from this analysis – shortcut/transit, program, and other because less than 50 cases across all three parks meant cell sizes were too small for a reliable nonparametric test.

[b] When a measure of association test is significant, different letters (A, B) on the observed value indicates a difference between the observed and expected frequency occurred between trail hub and park facility location using a z-test.

Next, exercise was examined more closely by classifying the physical activities of park user group into three separate levels (see Table 3). Physical activity levels were then assessed across zones by each park type. Vigorous physical activities were found to occur for a high proportion of uses at the trail hub area of the park compared to the park facility area. As shown in Table 6, at Park #1, the mature neighborhood and park, 66% of uses for Zone A included vigorous physical activities compared to 55% of Zone B uses (V=.11, p<.05). At Park #3, the young neighborhood and park, 88% of uses included vigorous compared to 65% of Zone B uses (V=.28, p<.001). Park #3 also had distinct zone associations for moderate and sedentary activities. Moderate (V=.34, p<.001) and sedentary (V=.20, p<.001) activities were more likely associated with Zone B compared to Zone A. Within the trail hub zone of Park #3, vigorous physical levels were three times higher than moderate and almost nine times higher than sedentary activity. Park #2, the destination park with a variety of recreation and eating facilities, exhibited no significant associations for the three levels of physical activity. Moreover, compared to the other two parks, Park #2 had the highest levels of moderate and sedentary physical activity levels.

Table 6. Physical activity levels by park and zone, multiple activities allowed in user group

	Park #1 – Mature		Park #2 – Middle-aged		Park #3 – Young	
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Vigorous Statistic Test[a]	65.8%A	54.7%B	55.6%	51.4%	87.9%A	64.5%B
	V=.11, p<.05		V=.04, ns		V=.28, p<.001	
Moderate Statistic Test	54.1%	59.9%	71.5%	62.3%	26.3%A	59.4%B
	V=.06, ns		V=.10, ns		V=.34, p<.001	
Sedentary Statistic Test	17.9%	24.5%	22.5%	21.3%	10.5%A	26.3%B
	V=.08, ns		V=.01, ns		V=.20, p<.001	

ns- not significantly different

[a] When a measure of association test is significant, different letters (A, B) on the observed value indicates a difference between the observed and expected frequency occurred between trail hub and park facility location using a z-test.

The social context of park uses was examined at the trail hub and park facility areas of the park. As shown in Table 7, Park #3 was the only park that held distinct differences of the individual or group using a trail hub in comparison to a park facility area. Those who were alone at a park were two times more likely to be in the trail hub area (61%) compared to park facility area (28%) (V=.11, p<.001). Family groups were more likely to be in the park facility area (46%) compared to trail hub area (25%), which was similar for friend groups (17% vs. 9%). The presence of children in the group was significantly associated with the use of the park facility area (24%) of park #3, as compared to the trail hub area (9%) (V=.08, p<.01).

Table 7. Social context of park uses by park and zone, survey uses data

| | Park #1 – Mature | | Park #2 – Middle-aged | | Park #3 – Young | |
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Social Unit (multiple response allowed)						
Alone	53.8%	45.0%	57.3%	49.3%	61.1% A	28.0% B
Statistic Test[a]		V=.09, ns		V=.08, ns		V=.33, p<.001
Family	31.6%	37.2%	33.3%	38.1%	25.3% A	45.7% B
Statistic Test		V=.06, ns		V=.05, ns		V=.21, p<.001
Friends	11.5%	16.2%	9.9%	10.7%	8.9% A	17.2% B
Statistic Test		V=.07, ns		V=.01, ns		V=.12, p<.05
Children in social unit	15.0%	14.1%	11.1%	13.5%	8.5% A	24.3% B
Statistic Test		V=.00, ns		V=.04, ns		V=.08, p<.01

[a] When a measure of association test is significant, different letters (A, B) on the observed value indicates a difference between the observed and expected frequency occurred using a z-test.

To further examine physical activity levels and the social context of park and trail use, several time measures were examined with the same analytical format. Table 8 provides results for testing proportional use levels by type and time of day. Trail hub and park facility zones were found to be similar for the type of day across all three parks, which is expected given the systematic sampling approach. Similar results for the testing zones were found for time of day across two of the three parks. At Park #3, the park facility zone had significantly higher proportional use levels (25% of uses) during the afternoon compared to the trail hub zone (15%) (V=.14, p<.05). This finding could be attributed to a spray park in the park facility zone which attracted children and adults, even during the hottest time of the day.

Lastly, park users were asked to estimate the length of time they would be spending or had spent at the park during that particular visit and how number of park visits made by them in the past 30 days. For those who participated in vigorous activities, the length of time was converted into a measure of whether or not a single visit met the recommended weekly minimum of 75 minutes and tested between zones. As shown (Table 9), the range of park visit length was extensive. The proximity of parks to housing and schools created some very short visits (3 min to 15 min for minimums); and long distance cycling created much longer visits (180 min to 360 min for maximums). Medians and means were estimated. Only for Park #1 did minutes in the park differ by zones (Zone A: 74 minutes vs. Zone B: 60 minutes, t=3.4, df=414, p<.001). For vigorous activities which met recommended weekly levels, Park #1 had a higher proportion (V=.24, p<.001) of users (31%) in the trail hub zone compared to park facility zone (11%). For visiting history to the park, users using weighted data averaged approximately three to four visits over 30 days (Table 8). No significant zone differences were estimated.

Table 8. Temporal measures by park and zone

	Park #1 - Mature		Park #2 – Middle-aged		Park #3 - Young	
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Type of Day[a]						
Weekday	45.5%	49.5%	36.3%	44.4%	45.8%	47.0%
Weekend	54.5	50.5	63.7	55.6	54.2	53.0
Statistic Test						
	V=.04, ns		V=.08, ns		V=.01, ns	
Time of Day[b]						
Morning	36.6%	36.5%	33.3%	40.3%	52.1%	49.7%
Afternoon	24.7	18.8	21.1	21.8	14.7A	24.9B
Evening	38.7	44.8	45.6	38.0	33.2	25.4
Statistic Test[c]						
	V=.08, ns		V=.08, ns		V=.14, p<.05	

[a] Sample frame was equal amounts of time at each park and zones. Six survey days for weekdays (Monday through Thursday); and six survey days for weekend (Friday through Sunday).

[b] Four survey days for each time of day. Morning hours 7 to 11 am; afternoon hours 11 am to 3 pm; and evening hours 3:30 to 7:30 pm.

[c] When a measure of association test is significant, different letters (A, B) on the observed value indicates a difference between the observed and expected frequency occurred between trail hub and park facility location using a z-test.

Table 9. Length of current visit and experience use history with park by park and zone, survey data

	Park #1 - Mature		Park #2 – Middle-aged		Park #3 - Young	
	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities	Zone A Trail Hub	Zone B Multi-purpose Facilities
Length of current visit (minutes)						
Min	3	15	10	4	10	5
Max	240	300	180	360	180	240
Mean[a]	74	60	62	68	76	68
Statistic Test	t=3.4, df=414, p<.001		t=1.4, df=366, ns		t=1.9, df=362, ns	
Proportion of uses that meet recommended weekly minimum (75 min.)	31.3%A	10.8%B	18.7%	17.6%	33.5%	29.7%
Statistic Test[b]	V=.24, p<.001		V=.01, ns		V=.04, ns	
Experience use history (park visits in 30 days)						
Mean	3.3	3.8	3.8	3.4	3.3	2.5
Statistic Test	t=0.6, ns		t=0.4, ns		t=1.1, ns	

[a] The median for all park-zones was 60 minutes.

[b] When a measure of association test is significant, different letters (A, B) on the observed value indicates a difference between the observed and expected frequency occurred between trail hub and park facility location using a z-test.

DISCUSSION AND CONCLUSION

The aim of this study was to examine the contribution of park structural features in achieving high (vigorous or moderate) physical activity levels and investigating the social behavior of park user groups through measures of park visitation. Over the past fifteen years, there has been a remarkable increase in empirical research on parks and well-being using various research methods in a variety of locations and types of parks. These studies have primarily been conducted in the United States given growing concern over obesity, medical access and costs, and dependency on personal vehicles over active transportation. Empirical studies are needed to review policies to inform urban planning, park management, and marketing to achieve a higher quality of life. The investments made by park agencies and the Robert Wood Johnson Foundation have provided evidence of parks' contribution to active lifestyles (e.g., Cohen et al., 2016; Larson et al. 2016) and are a social place in most communities (Kazmierczak 2013). The body of research, however, also suggests that not all parks and trails are the same and that park use varies by the type of its facilities, the quality and care of parks, type of neighborhood where the park or trail is located, and urban versus rural settings.

This research contributes to the literature by extending the U.S. research to a global city where land use policy and park planning has been recognized as exemplary. In the case of Singapore, the involvement of several land management, planning and park agencies has proven vital to creating a biologically diverse urban environment with extensive park access to its populace. Neighborhoods across the island, both old and new, illustrate contemporary installations of park facilities and natural environments as a demonstration of "A City in a Garden". The large regional parks designed during the city's early planning, such as Bedok in the 1960's and Bishan-Ang Mo Kio in the 1980's, were later connected to other parks and neighborhood features with the Park Connector Network established in the 1990's. Ackley (2014) and Cranz and Boland (2004) recognize that parks are products of an era with socially embedded urban planning. A park's utility is likely to decline over time if modifications are not made. New social-ecological frameworks, such as Cranz and Boland's, are tools for planners, engineers, and ecologist to redesign old parks and design new parks to be relevant to people, particularly supporting sports and physical activities and places where people socialize with family and friends.

The findings of this study highlight the difference between old and new parks and the influence of trail hubs on park use and users. As this study shows, two trail hubs, which were modifications of existing parks, were converted into a broader multi-purpose way, therefore a renewal of what might have been previously underutilized public area. The oldest park (Park #1) studied had significantly higher levels of exercise as a reason to visit the park and vigorous physical activity levels. The newest park (Park #3), where trails had already existed in the neighborhood and a trail hub provided access to it, showed the most promise in terms of physical activity levels. Almost nine out of ten user groups at the trail hub in that park did some form of vigorous activity. This park is unique in that its linearity mimmicks a trail and then has selected park features (playgrounds, bathrooms) designed along its corridor. While trail hubs increased vigorous physical activites in two of the three parks studied, moderate levels physical activities were evident in over 50 percent of the park usage at all three parks except for the trail hub zone of Park #3. Sedentary activities held the lowest proportions (under 30%) of park usage at these parks. These findings are

in stark contrast to Floyd et al.'s (2008) in two U.S. cities with 70 percent and 51 percent levels of sedentary behavior in parks.

The dominant park user was the solo park user across the two zones at each of the three parks. This finding is particularly amplified by the trail hub area of the newest linear park. This area had the highest level of vigorous activity with cyclists, joggers, and runners frequenting the area. Interestingly, the high proportion of solo park users could be a reflection of park users' perception of safety toward the space. Park planners should particularly consider linear park design with trail hubs allowing connectivity to other nearby trails and other amenities which are attractive to active users such as water stations, rest rooms, bike racks, lighting, and stretching and exercise areas. Trails and park design can also bring people residing beyond the neighborhood and encourage non-motorized activities over car access. At the oldest park, a paved parking lot was next to the trail hub and offered access into the park and PCN, whereas the other two trail hubs studied were without a parking lot near the trail hub studied. The length of time spent in the park did not differ across zones, except at one of the parks. At the oldest park in the oldest planned neighborhood, the proportion of users who met the recommended weekly minimum of vigorous physical activity was three times higher at the trail hub zone than the other zone. This is particularly important because this park was near many older households and offered parking lot access for those living further away.

Surprisingly, the middle-aged park had no significant physical activity or social demographic differences between the trail hub zone and the multi-purpose zone. Bishan-Ang Mo Kio has the largest land size amongst the three parks studied, but is not the most densely populated. At the multi-purpose area of the park, there is almost equal proportions of adjacent, nearby, and outside residents compared to the other five study sites. This shows that while serving as a local park, it is also a destination park to many. The sample sites within the park were different in their characteristics and several kilometers from each other. The trail hub at Bishan did not have a Fitness Corner or toilet, unlike Bedok's, which may have discouraged active park users to travel via the trail hub, and instead were dispersed across the entire park.

Lastly, the study's limitations must also be taken into account in interpreting the findings and conclusions. One challenge is achieving "experimental" conditions for field park data collection. For example, studying a particular treatment is feasible when a park has only one particular type of condition or facility. For *in situ* studies involving large parks, although efforts to focus on primary features such as a trail hub are possible, the conditions for data collection cannot be fully controlled. Similar to Shores and West's (2010) study, the parks studied in this research offered many facilities, including trails that were present everywhere. Moreover, this study aimed to be externally valid by using multiple parks and more than one fixed area within a park. Another challenge comes from Lee and Maheswaran (2010) who have critiqued that most park and physical activity studies are correlational analyses and are therefore not true experiments. This study used experimental design features (i.e., a trail hub treatment in comparison to a more generalized park area) that allowed some control over park type and facilities in the analysis, although the results do not deliver on estimating cause and effect relationships. To effectively investigate the cause and effect relationship between park and trail design with physical activity and social characteristic of park users, future studies can consider embarking on prospective or intervention studies. As Starnes et al (2011) argues, the measurable effect of trails on physical activity levels takes time to

be demonstrated. It would thus be useful to conduct a study to allow for a closer examination of the effects of trail use over time.

As cities continue to urbanize, parks and green spaces face increasingly intense land use competition especially in smaller cities like Singapore. Proper planning of the urban environment can, however, encourage greater use of these outdoor spaces. First, trails and trail hubs, which would tend to be located in newer urban areas, can reach more people living at the edge. A trail network provides many places to integrate existing or new parks which can increase overall accessibility. Second, trail hubs are important staging areas that provide either a starting or ending point to an outdoor physical activity experience, or may even be a transitional intersection within a larger network giving users the option of visiting parks, which may lead to a longer duration of physical activity. Finally, as the segment of people involved in vigorous physical activities (e.g., running, cycling, water trails for kayaking) that require longer distances grows, there is potential relevance for a park and trail system to be designed to keep users within the park system.

This study contributes to a growing number of empirical studies across a wide geography which have shown that parks play a favorable role in achieving better health conditions through physical activity (Sugiyama, Leslie, Giles-Corti & Owen, 2009; Han, Cohen, McKenzie, 2013; Cohen et al., 2016; Lincoln et al., 2016). Hopefully, this compelling evidence would encourage additional public investment in parks and other places where human powered physical activity occurs outdoors in nature as a "green gym" (e.g., sidewalks, trails, navigable waters, walkable downtowns) as a means of improving well-being and quality of life.

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