

## **ABSTRACT**

OLIVEIRA ALBERICO, CLAUDIA. A Spatio-temporal Analysis of Youth's Park-based Physical Activity in Parks within Low-income, Diverse Neighborhoods. (Under the direction of Dr. J. Aaron Hipp).

Physical activity is an essential tool in addressing the worldwide obesity epidemic. During childhood, the numerous health benefits of children's active behavior (at light, moderate, or vigorous intensities) include decreased cardio metabolic risk factors, decreased adiposity, improved physical fitness, better bone density, enhanced cognitive performance, and increased mental well-being. Additionally, youth with a higher physical activity index also have greater odds of being active in adulthood. Thus, there are guidelines recommending that children should accumulate 60 minutes of moderate-to-vigorous intensity physical activity per day, which applies to all children and youth, irrespective of gender, race, ethnicity, or income level. However, fewer than 25% of children in the United States (U.S.) ages 6-17 are sufficiently active. Social injustices frequently result in girls, youth of color, and those in low-income families suffering from lower chances of being physically active. Neighborhoods and communities can have structures and adequate spaces that promote physical activity for all but there is key information missing on how diverse youth make use of available spaces for physical activity. To understand how park facilities can support physical activity in low-income communities, we need to design studies that assess both space and physical activity. The majority of studies have been focused on the use of direct observations and self-reported methods. Device measures using accelerometers and GPS have been focused specifically on schoolyards or conducted for a full week of free-living assessment. I could not find any reports of studies designed for the objective assessment of park use and park-based physical activity in children in low-income communities of color. So, in this dissertation, I aimed to describe youth spatio-temporal use of park features and their physical activity in low-

income, diverse neighborhood parks. This aim was addressed by three objectives. The first, to describe a multi-method, multi-site study of parks in low-income communities of color that adds to the body of knowledge in research via direct observations, device measurements, and electronic surveys. The second, to describe youth use of features by individual temporal characteristics and physical activity. My results indicate that boys and girls used playground sets and splash pads similarly. Swing sets comprised the most used feature by girls, while basketball courts had higher proportions of boys. The third, to describe 5-10-year-olds' physical activity by individual, temporal, and spatial characteristics. Light activity was the most prevalent level of physical activity in parks, followed by moderate and vigorous physical activity. Girls were more sedentary, boys were more active. Basketball courts, games, and swing sets were the features where moderate to vigorous activity were more prevalent. Describing the feature use by youth as well as park-based physical activity in low-income, diverse neighborhoods provides evidence to inform practice on park design, renovations, and programming. Additionally, researchers can use these results to improve methods and develop interventions targeting under-resourced populations.

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A Spatio-temporal Analysis of Youth's Park-based Physical Activity in Parks within Low-income, Diverse Neighborhoods

by  
Claudia Oliveira Alberico

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APPROVED BY:

---

J. Aaron Hipp (Committee Chair)

---

Myron F. Floyd

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Bethany Cutts

---

Jasper Schipperijn

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Perver K. Baran

## **DEDICATION**

To my parents, who always taught me to persevere.

## **BIOGRAPHY**

Claudia Oliveira Alberico was born and raised in Southern Brazil. Always curious, Claudia grew up loving to read and learn. Her goal in life is to help make a difference in the world, to make people healthy and happy.

## ACKNOWLEDGMENTS

There was a great deal of collaboration throughout the development of this work. First, Dr. Myron F. Floyd and Dr. J. Aaron Hipp were responsible for conceptualizing and securing funding for the PARC<sup>3</sup> Project in partnership with the Physical Activity Research Center (PARC). Without their leadership and guidance there would be no PARC<sup>3</sup> Project.

I want to acknowledge the team at NC State responsible for being the engine pieces that moved the project along: Beth Mazak, Oriol Marquet, Jing Huang, and myself. Together we were able to develop protocols and manage data collection in North Carolina and New York. However, we could not have accomplished these tasks without the help of Dr. Gina Lovasi and Dustin Fry, who were in the forefront of the New York data collection and personnel management.

I would like to express gratitude and attribute the hard work of conducting observations and entering data to each and every one of the research assistants: Tyiesha Battle, Summer Faircloth, Melissa Tobias, Gian Spells, Cameron Smith, Zack Russell, Jack McCallister, Jordan Diard, Daniel Woody, Tyler Johnson, Ray Person, Anyelina Cantos, Cheryl Bennett, Emil Fraija, Jody Bayer, Melika Behrooz, and Tammy Kouffman. Also Jiawei Xia, who worked as an interpreter for those participants who preferred to respond in Mandarin Chinese.

Special thank you to Raleigh Parks, Recreation and Cultural Resources, Durham Parks & Recreation, and New York City Department of Parks and Recreation for their support throughout the planning phase of the project. The HABITUS platform was essential in finalizing data management. Data processing for accelerometer and GPS data was made possible via Dr. Jasper Schipperjin at the University of Southern Denmark.

This dissertation was a result of ongoing collaborations with the PARC multi-university research team. PARC aims to build the evidence base for policy changes and practices that will help make physical activity part of everyday life for all children, with a special focus on children who typically have fewer opportunities to be active (<http://paresearchcenter.org>). Financial support for this research was provided by the Robert Wood Johnson Foundation. The views expressed here do not necessarily reflect the views of the Foundation.

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## CHAPTER 1: INTRODUCTION

### Background

Fewer than 25% of American youth ages 6-17 are sufficiently active, with a significant decrease from 42% at age 6 to 5% at age 19 (National Physical Activity Plan Alliance, 2018). As a result, more than 75% of youth are not achieving the recommended level for sufficient physical activity of daily 60 minutes of moderate-to-vigorous intensity (Bull et al., 2020). This guideline is irrespective of gender, race, ethnicity, or income level (Piercy et al., 2018). However, various barriers, constraints, and biases exist preventing equal access to facilities and reducing the opportunity to be physically active for some demographic groups. For example, national data have suggested that living in a low-income neighborhood is associated with low levels of moderate-to-vigorous physical activity in individuals 13 years to 25 years old (Armstrong et al., 2018). Additionally, physical activity levels decrease with age from childhood to adolescence (Sember et al., 2020). Avoiding limitations on physical activity is a challenge especially for girls. Boys were found to be more active overall (Brooke et al., 2016) and two times more likely to meet the guidelines for physical activity than girls (Ishii et al., 2015). Asian, Black, and Latino youth, on average, have the highest proportions of insufficient physical activity: nearly 85%, 79%, and 79% are not meeting WHO recommendations, respectively (Centers for Disease Control and Prevention, 2019). This physical inactivity in youth may be exacerbating the health inequalities faced in adulthood, particularly by women and communities of color. As such, I sought to understand park-based physical activity of youth in parks located in low-income communities of color.

Physical activity is an essential tool in reducing the worldwide obesity epidemic. Obesity is a public health concern across the globe, specifically in youth (Kohl et al., 2012; Oreskovic et al., 2015). The numerous health benefits of active behavior include decreased cardio metabolic

risk factors, decreased adiposity, improved physical fitness, better bone density, enhanced cognitive performance, and increased mental well-being (Poitras et al., 2016). Additionally, youth can benefit from the improved motor development, enhanced cognitive functioning, increased academic performance, and better psychological health resulting from physical activity (Roychowdhury, 2020). Moreover, youth with a higher physical activity index also have higher odds of being active in adulthood (Telama et al., 2005).

Differing levels of physical activity have been associated with sociodemographic characteristics (Kowaleski-Jones et al., 2017) which may be due to disparities in the availability of exercise facilities (Casey et al., 2012; Gordon-Larsen et al., 2006). Temporal aspects have also been found to affect active behavior. For example, a comparison of activity during the school year versus during summer break found that physical activity was lower in the summer and that this was most likely related to the reduction in enjoyment of physical activity during this time of the year (Sallis et al., 2019). Additionally, certain elements of the built environment have been associated with higher levels of physical activity in youth. These elements include availability of physical activity facilities (Casey et al., 2012), neighborhood walkability, the speed and volume of traffic (Ding et al., 2011; Van Dyck et al., 2013), and access to parks (Bedimo-Rung et al., 2005; Kaczynski et al., 2008). Children account for more than 30% of park users in the U.S. (Evenson et al., 2016; Joseph & Maddock, 2016).

The facilities within parks potentially prompt active behavior (Bancroft et al., 2015). Playgrounds, open spaces, picnic areas, sports fields, and courts are the structures within parks that children use more often (Floyd et al., 2011). Girls reportedly use swings and slides most often, while boys choose to play in fields (Loukaitou-Sideris et al., 2010). A higher proportion of White youth was less active than other race/ethnicity youth groups in open spaces (Kaczynski et al.,

2013). As a majority of the research in child use of parks and park spaces for physical activity has been conducted in middle and upper income areas, as well as White neighborhoods (Andersen et al., 2015; Czalczyńska-Podolska, 2014), the field may lack an evidence base concerning how children in low-income communities of color are using available park spaces. Thus, more research on environmental characteristics that stimulate park-based physical activity must be performed in those communities.

In addition to limited diversity in the data population supporting park-based physical activity in children, there are also multiple methodologies employed by the field(s) to evaluate the use of space and physical activity. To best understand how park facilities can support physical activity in low-income communities of color, we need to design studies that assess both space and physical activity. The majority of studies have been focused on direct observations and self-reported methods (Azlina & Zulkiflee, 2012; Cohen, Han, Nagel, Harnik, McKenzie, et al., 2016; Czalczyńska-Podolska, 2014; Evenson et al., 2016). Direct observations are beneficial for capturing space use, but suffer because they rely on observer perception to report physical activity level and demographics (Harris, 2002). On the other hand, self-reported methods may improve robustness of some variables, including demographics, but limit activity to participant recall, which may be overestimated (Haskell, 2012).

There are limited studies employing objective measures using devices (accelerometers and GPS). Those have been focused specifically on schoolyards or were designed to examine a full week of free-living assessment (Andersen et al., 2015; Dunton et al., 2014), and I have not found any other studies using devices as a methodology to assess park use and park-based physical activity in children in low-income communities of color. Thus, I have focused on parks and park features that support youth's park-based physical activity as the behavior outcome.

I am particularly focused on filling two gaps. First, the limited evaluation by previous studies of parks in communities of color. Here, I focused on 40 parks all located in low-income communities of color. Second, the lack of information needed to support alternative methodologies useful in the study of park-based physical activity. I used two specific methods in the investigation of park-based physical activity: systematic observations and accelerometry combined with GPS monitoring.

### **Purpose and Objectives**

In this dissertation, I aim to describe youth spatio-temporal park feature use and park-based physical activity in low-income communities of color. Features in this context refer to the facilities within park boundaries where physical activities could potentially take place, e.g. playground sets, courts, and fields. *Park-based physical activity* is any level of behavior or activity, from sedentary to very vigorous, that takes place inside park boundaries. My overall aim is addressed by three research objectives, each represented by an individual manuscript. These objectives are:

- a) To describe the Physical Activity and Recreation in Children in Communities of Color (PARC<sup>3</sup>) Study, a multi-method, multi-site study of parks in low-income communities of color;
- b) To describe the systematically observed youth use of park features, stratified by age, gender, race/ethnicity, physical activity levels, and temporal characteristics (time of the day, day of the week, and season) within low-income communities of color; and,
- c) To describe 5-10-year-olds' device measured park-based physical activity, stratified by age, gender, race/ethnicity, temporal characteristics (day of the week and season), and spatial features of parks in low-income communities of color.

## **Author Contributions**

For the studies presented in this dissertation I used secondary data from a broader project, the Physical Activity and Recreation in Children in Communities of Color (PARC<sup>3</sup>). All of those involved contributed in the capacities listed:

- Conceptualization: Alberico, C.O.; Methodology (PARC<sup>3</sup>): Alberico, C.O., Hipp, J.A., Floyd, M.F., Marquet, O., Mazak, E.; Software: Schipperijn, J.;
- Formal analysis: Alberico, C.O.;
- Investigation (PARC<sup>3</sup>): Alberico, C.O., Hipp, J.A., Floyd, M.F., Marquet, O., Huang, J.H., Mazak, E., Fry, D.;
- Data curation (PARC<sup>3</sup>): Alberico, C.O., Fry, D., Marquet, O.;
- Writing – Original draft: Alberico, C.O.;
- Writing – Review & Editing: Alberico, C.O., Hipp, J.A., Floyd, M.F., Baran, P.K., Cutts, B., Schipperijn, J.;
- Supervision (PARC<sup>3</sup>): Floyd, M.F., Hipp, J.A., Losavi, G., Robinson, W.; Project Administration: Floyd, M.F., Hipp, J.A., Mazak, E.; Funding Acquisition: Floyd, M.F., Hipp, J.A.

## **Dissertation Organization**

This dissertation comprises the following chapters: Introduction, Literature Review, Study I, Study II, Study III, and Conclusion. Each of the three studies addresses one of the three research objectives. In the first study I describe the protocols, instruments, opportunities, and challenges in collecting data from individuals in parks located in low-income communities of color. In my second study, I use observational data to describe the proportion of children using park features (e.g., playgrounds, fields, and swings), stratified by gender, age, race/ethnicity, physical activity

levels, period of the day, day of the week, and season. For my third and final study I employ devices as a novel protocol to collect children's location and physical activity data during park visits in low-income communities of color. A description of participant characteristics and their physical activity levels is included, in which I further explore the potential of these data to inform park feature renovation and maintenance. Finally, in the conclusion I discuss my findings from this dissertation as well as future studies and implications.

## CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

### Overview

Children's park feature use and park-based physical activity are the central themes of my dissertation. The aim, to describe youth spatio-temporal feature use and park-based physical activity in low-income communities of color, encompasses many aspects of social and environmental domains. It is my purpose in this dissertation, to an extent, to highlight the interdisciplinarity of the subject of people and the environment.

The fields of Parks and Recreation, Public Health, Preventive Medicine, Design, and Urban Planning overlap in the study of youth physical activity and parks. Terms related to parks ("open space"; "green space"), physical activity ("motor activity"; "exercise"; "energy expenditure") and child ("children"; "youth") were used to retrieve published peer-reviewed articles for this review chapter. The terms used in the literature guided me in my work on this dissertation and will be used throughout. For example, "children" is used to refer to younger children (0-13 years old). "Youth" may refer to older children (teens) or a combination of all (0-19 years old). "Parks" are considered open, public, free spaces with structures designed for play that afford physical activity. "Features" correspond to those structures within parks, built (e.g., a playground set) or natural (e.g., a patch of grass).

### Literature Review

#### *Youth Physical Activity: Prevalence, Correlates, and Determinants*

A large proportion of youth is considered insufficiently active: Approximately 75% of children 6-17 years old (National Physical Activity Plan Alliance, 2018) and approximately 60% of children 6-11 years old are not compliant with physical activity recommendations in the U.S. (Katzmarzyk et al., 2016). To encourage these active behaviors in individuals of all ages, the World

Health Organization provides guidelines by age group. The recommendation is that youth should have 60 minutes of accumulated moderate-to-vigorous intensity physical activity every day; bone and muscle-strengthening activities should be completed at least three days per week (Bull et al., 2020). The promotion of these health behavior recommendations is a relevant strategy for addressing the risks associated with obesity in youth, which in turn exposes them to an increased risk of developing non-communicable diseases during adulthood.

Though the physical activity guidelines are applicable to all children and youth, irrespective of gender, race, ethnicity, or income level, some sociodemographic groups have been observed to have a greater chance of not being physically active due to a lack of access and opportunity and, therefore, are at a higher risk of developing chronic disease. Due to social and environmental injustices, health inequalities are widespread and continually increasing (Ford et al., 2019). Early data from NHANES collected in 2003-2004 showed that the achievement of the specific physical activity recommendation ranged from 2% among 12-15-year-old non-Hispanic White girls to 61% among 6-11-year-olds who identified as non-Hispanic Black (Whitt-Glover et al., 2009). These results were surprising as there was an expectation that non-Hispanic White youth would present higher levels of physical activity, yet this was not the case. I presume that these discrepancies are due to the comparison of self-reports with accelerometer data. The first can often be overestimates, while the second includes all domains of activity and can be more comprehensive. NHANES data from 3,106 participants from 2004 to 2006 showed physical activity levels of most Latino youth to be lower than that of most White and Black youth (Belcher et al., 2011; Harrolle et al., 2013). In later data (from 2007-2016) from the same survey, a majority of female Black youth and Latino youth reported the lowest percentage of moderate-to-vigorous physical activity. The lower rates of physical activity were reported by the majority of low-income

females as well (Armstrong et al., 2018). A decrease in physical activity with age was also reportedly twice as prevalent for most Black girls when compared to most White girls (Lown & Braunschweig, 2008). Physical activity levels, therefore, are statistically related to gender, age, race/ethnicity, and income.

Physical activity has the potential to increase life expectancy by almost one year (Lee et al., 2012) should inactive populations worldwide become active. The numerous health benefits of physical activity include the aforementioned prevention of obesity and its related conditions, prevention of cardiometabolic risk factors, improved bone density, cognitive performance, and mental well-being (Janssen & LeBlanc, 2010; Lubans et al., 2016; Piercy & Troiano, 2018). Furthermore, youth can benefit from adherence to health behavior recommendations, which include physical activity (Hardy et al., 2017), to reduce the risk of adult non-communicable disease and increase their chances of living healthier, active adulthoods. Children have a better chance of maintaining active behaviors throughout their adult life when they have a good level of physical activity during childhood. This was identified in a longitudinal study with a large sample of boys and girls (n=2309) who were examined from 3 to 18 years old (Telama et al., 2005). The researchers found that the higher the physical activity index maintained by participants during childhood, the greater their odds of being active in adulthood. This reinforces the need to effectively support individuals at young ages to promote physical activity in youth and help them remain active throughout the lifespan.

Nonetheless, a significant decrease in meeting the recommendation for physical activity has been observed with increasing age, from 42% at age six to only 5% remaining active at age 19, with girls on average being less active than boys overall (National Physical Activity Plan Alliance, 2018). National data have suggested that physical activity levels decrease with age for

children and adolescents (Sember et al., 2020). A longitudinal study indicated a decline in moderate-to-vigorous and total physical activity between ages 10 and 14, especially during weekends and off-school times (Brooke et al., 2016).

More than sociodemographics can affect children's ability and decision to be physically active. The socioecological model for physical activity (Baumann et al., 2012) provides a lens that incorporates layers of intrapersonal, interpersonal, environmental, regional, national, and global policy as correlates and determinants of physical activity. Ecological models can highlight the range of potential influences on behavior, including those determined by unique contexts in which active behavior occurs (Atkin et al., 2016). Environmental aesthetics and the presence of suitable play affordances are important factors that facilitate children spending time outdoors (Hayball et al., 2018), which is known to promote active behavior (Gray et al., 2015), especially true for those of low socioeconomic status (Aggio et al., 2017). Both boys and girls have been found engaged in higher levels of physical activity in green environments such as parks, gardens, grasslands, and farmland (Coombes et al., 2013).

### ***Park Use and Youth Physical Activity***

Parks have been shown to be a significant location for physical activity and of benefit to public health (Bedimo-Rung et al., 2005). An average of 30% of observed park users are children (Evenson et al., 2016; Joseph & Maddock, 2016), especially in low-income neighborhoods (Camargo et al., 2018). Children's use of parks and greenspaces was found to be low (3.5% on average) when compared to their time spent in other domains such as home (49%) and school (26%). However, those researchers also reported that children spent, on average, 35% of their time in parks and open recreation areas in moderate-to-vigorous physical activity, a much higher proportion than home (13.5%) or school (16%) (Perry et al., 2016).

Fewer than 50% of participants reported being physically active in parks in a study whose researchers sought to identify the locations and physical activity of its participants via accelerometers and self-report of locations (Colabianchi et al., 2016). Researchers have also used GPS devices to capture children's physical activity in open spaces such as parks. In New Zealand, 176 children 5-10 years old were assessed over one week. Only 1.9% of their recorded activity was identified as being in city parks, with obese children demonstrating slightly more activity (2.7%) (Quigg et al., 2010). A study of Swiss children indicated that they spent only 2.3% of their time in parks. Swiss children accumulated 297 minutes of moderate-to-vigorous physical activity during a week of measurement, and a median of five of those minutes were spent in parks (Bürgi et al., 2015). Although parks may not seem to be a large source of moderate or vigorous physical activity (MVPA) during daily or weekly visits for children, the presence of parks within neighborhoods and youths' use of those spaces have been shown to significantly increase physical activity.

Dunton et al. (2014) reported that, even though 54% of 135 parent-child dyads lived within 500m of a park, only 27% of the 73 participants had used a park for at least 5 minutes during the week of Dunton et al.'s study. However, those that stayed at least 15 minutes (16% of the sample) engaged in at least 15 minutes of MVPA during their park visit (Dunton et al., 2014). Thus, there is evidence that, when youths visit parks, their chances of being physically active seem to improve. Nonetheless, safety is often cited as a constraint or a concern, especially for parents of young children. Groshong et al. (2020) used focus group methodology to understand the perceptions of safety from park users in Missouri. Though social interactions may facilitate park use, a lack of maintenance, incivilities, and concerning behaviors constituted reasons why parents in the focus groups would not allow their children to play in parks (Groshong et al., 2020). There is a potential

for increasing park use thereby physical activity by designing and maintaining better play spaces for youth.

### ***Youth Physical Activity and Park Design***

Although researchers have focused on physical access to parks, under the premise that more parks will increase physical activity, there is evidence that improvements to the facilities within a park could sustain active behavior (Bancroft et al., 2015). Park renovations have been shown to increase the number of park users, especially children (Cohen et al., 2015). Recent studies indicate the specific impact of playground spatial features, including the type of facilities and ground cover, on children's play. Andersen et al. (2015) monitored Danish children in the 5<sup>th</sup> grade to the 8<sup>th</sup> grade during school recess and found that the grassy areas and the playgrounds were where most MVPA was performed. In Europe, playgrounds that were supervised, equipped, and organized were less empty, had higher child use density, and users were more physically active, especially girls (Boonzajer Flaes et al., 2016). It is important to distinguish playgrounds by their settings: although generally they are locations where children can play which may include swings, slides, and other features, within parks playgrounds are often complex structures in which multiple movements are possible (but each movement-related structure is considered as a set on their own), such as climbing, running, sliding, and jumping.

Veitch et al. (2020) used walk-along interviews in nine Australian parks to identify children's opinions on the importance of park features, and found that visitation could be encouraged by challenging and interesting play equipment, water play areas, trees and shade, and full-sized basketball courts. Features most valued for physical activity included fields and courts, open spaces, trees, and other natural elements (Veitch et al., 2021). In the U.S., Floyd et al. (2011)

observed variation in park-based physical activity by park zones, and reported that features such as playgrounds, open spaces, picnic areas, sports fields, and courts were mostly occupied. Overall, playgrounds seem to be the park feature where girls are more likely to be observed (Floyd et al., 2011; Loukaitou-Sideris & Sideris, 2010). Baran et al. (2013) assessed 20 neighborhood parks and found that an increase in the size of park zones by one standard deviation was associated with an increase of 52% in the number of boys who used the park. Basketball courts were associated with a large proportion of a park's use by boys and playgrounds were the most attractive feature for all (Baran et al., 2013).

Cohen et al. (2020), in their national study of parks, found that spinning structures and splash pads were associated with a greater use of playgrounds and higher levels of MVPA. Many of the studied playgrounds are within school boundaries or are studies of playground locations (Andersen et al., 2015; Boonzajer Flaes et al., 2016; Veitch et al., 2021), not structures as previously defined. Frequently adults and older adults are studied (not children and youth) in park settings (Zhai et al., 2020, 2021) even though, on average, youth are more active (52%) than adults (38%) when in parks (Kaczynski et al., 2011; Roemmich et al., 2014). Designing better play spaces for youth may thus increase park use and, consequently, physical activity.

There is lack of specificity in the understanding of feature use in neighborhood public parks, especially in low-income communities of color. Youth active behavior inside neighborhood parks and their structures merit further research as park design and physical activity in youth need to be better explored to identify potentials for future interventions.

### ***Youth Park Use, Park-Based Physical Activity, and Park Design: Methodologies***

#### **Direct observations**

The majority of studies reporting information on the characteristics of playgrounds and their potential association with types of physical activity have used direct observations or self-

reported measures (Azlina & Zulkiflee, 2012; Czalczynska-Podolska, 2014; Joseph & Maddock, 2016). The System for Observing Play and Recreation in Communities (SOPARC) (McKenzie et al., 2006; Ward et al., 2014), for example, uses a well-established protocol that allows researchers to systematically observe predetermined target areas where physical activity is expected. In parks, “target areas” can be identified and observed for several hours on some or all days of the week. Typically, observations are obtained by trained researchers, who use the following process: 1) scan the area from left to right, counting the number of females within age groups, race/ethnicity, and physical activity levels; 2) repeat the first step for males. At the end of a scan, for example, the observer has tallied numbers of female children, female adults, and female older adults, along with the number of females being sedentary, in moderate activity, and in vigorous activity. Scans are performed in each target area every 15 minutes, for a total of four rounds in an hour. The scans enable researchers to build a generalizable picture of park use and park-based physical activity, including changes in park use over time as well as before and after interventions. This scanning technique is also an easy to employ and cost-effective tool to use in surveillance. For example, a group of researchers is committed to using direct observations to study park use and physical activity throughout the U.S. (Cohen, Han, Nagel, Harnik, McKenzie, et al., 2016; Evenson et al., 2019) with the intent to standardize measurements for better comparison.

However, although the direct observation method is somewhat inexpensive, it may not be feasible to observe park areas for several hours over a period of multiple days (Cohen et al., 2011). Moreover, although the tool is standardized, researchers will adapt the approach to fit their needs (e.g., age group categories) which lowers comparability of direct scan results between studies. For example, studies consistently report children to be mostly sedentary when in parks (Evenson et al., 2016) but this is potentially due to categorization, if all children and adolescents are aggregated

into one “youth” group. If, on the other hand, they are separated into younger (0-10 years old) and older (10+ years old) groups of children, more than 50% of the time younger children are observed in MVPA in parks (Joseph & Maddock, 2016; Moore et al., 2017). To address these differences, Joseph and Maddock (2016) reviewed the protocols being used in observational studies of parks and park-based physical activity. They found that age groups were often separated into “youth,” “adult,” and “senior.” More than 85% of studies using SOPARC obtained data from 7-day assessments, with four observation periods per day (Joseph & Maddock, 2016). However, research aimed at maximizing the quality of data while minimizing cost and time indicate that, to obtain a robust estimate of park use and park-based physical activity, a schedule of four days a week, four times a day is sufficient for any given period of time (e.g., week, season, etc.) (Cohen et al., 2011).

The direct observation method SOPARC acknowledges the use of space, i.e., the primary unit of analysis is the space and not the user of the space. Furthermore, direct observation can assess areas with a large number of users in a short period of time thereby ensuring minimal risk for participants. SOPARC is an excellent tool to measure changes in the use of space, both for who is using these spaces and how active they are when using them. Additionally, the observer, during the scan, is able to note the main activities being performed in the space.

#### Geolocation and Accelerometry

Combinations of devices capable of simultaneously measuring geographic location and movement forms another method for assessing physical activity and park use (Kerr et al., 2011). Participant-worn Global Positioning System (GPS) devices can capture the geographic position of users with an accuracy of two meters, depending on the device used and the density of the area (Jankowska et al., 2015; Schipperijn et al., 2014). Additionally, tri-axial accelerometers measure

any acceleration produced by the body, later translated into counts, which can be used to derive levels of physical activity. Computer-based geographical information systems (GIS) software and technology can be used as the primary methodology to measure, visualize, and analyze spatio-temporal data (Auchincloss et al., 2012). These techniques can be useful in measuring distances, creating buffers, and aggregating multiple spatial features.

Protocols on the use of GPS in combination with accelerometers in physical activity studies have suggested a more accurate and sensitive measurement approach by which researchers may identify environmental and behavioral contexts. A combined process involving the identification of location, the assessment of behavior and the incorporation of other spatial information through GIS enables researchers to explore exposure through time, space, and behavior (Jankowska et al., 2015). The concept of “spatial energetics” defines the incorporation of high-resolution spatio-temporal data on location and physical behavior, to examine how the environmental characteristics, space, and time can be linked to obesity-related health behaviors (James et al., 2016).

Physical activity studies using GPS and accelerometer devices have been able to capture active behavior (Dunton et al., 2013, 2014; Quigg et al., 2010) through assessments of schoolyards (Andersen et al., 2015; Dessing et al., 2013) or of free-living conditions, where participants wear the monitoring devices for a period of time (e.g., seven days) for their normal activities (Dunton et al., 2014; Ward et al., 2016). Measuring physical activity only of park users was found for older adults using pedometers (Zhai et al., 2020) as well as using an accelerometer and GPS (Zhai et al., 2021). I could not find any reports on device assessment of only park-based physical activity in children which led to a detailed understanding of use and activity across park spaces. Using objective measurements of park-based physical activity has the potential to eliminate observer bias

when conducting direct observations and also helps to avoid recollection gaps when children's activity is reported by a parent or guardian.

The use of GPS and accelerometer devices have been highly supported in the literature (Troped et al., 2010); the combination of GPS devices, accelerometers, and GIS provides a better understanding of behavior and setting. Furthermore, the use of GPS devices allows active or sedentary behavior to be paired with an immediate location, revealing what is being done (activity) and where it is taking place (location).

## **Theoretical Framework**

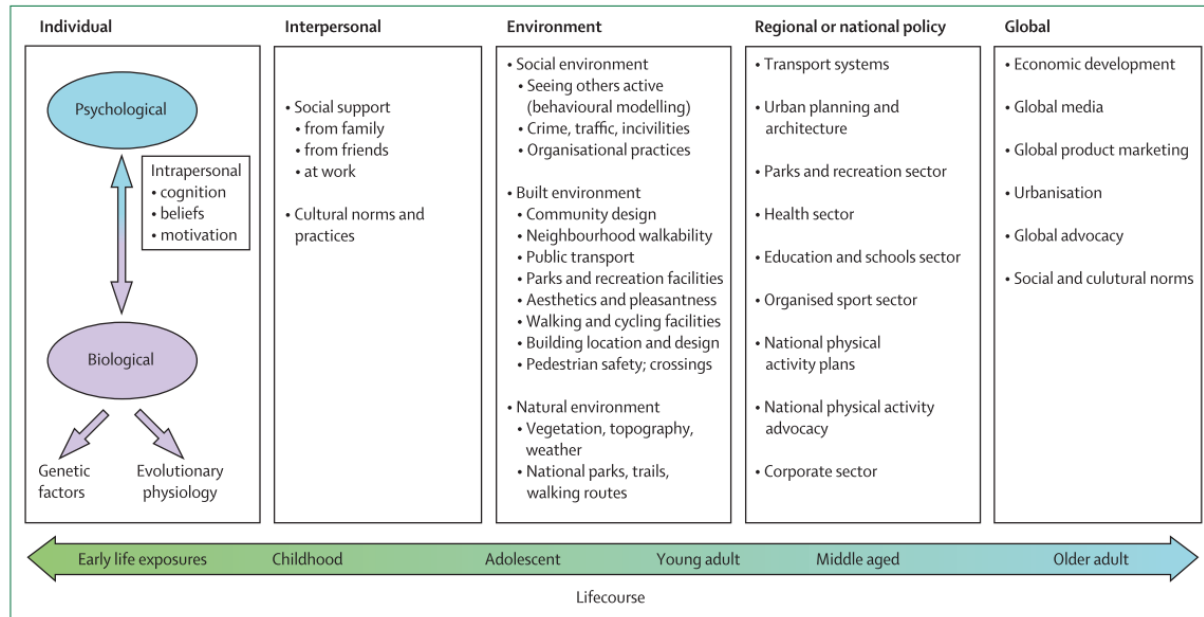
In this dissertation, I aim to describe youth spatio-temporal feature use and physical activity within parks located in low-income, diverse neighborhoods, stratifying both assessments by gender, age, and race/ethnicity (both perceived and self-reported). To achieve this, I employed two methodologies: perceived race/ethnicity by direct observation and self-reported race/ethnicity via parents/guardians in surveys. Socio-ecological models analyzing human behavior as a complex outcome of interactions have been presented since the 1970s and have enabled the understanding that these processes are complex, reciprocal, and interactive between a human being and the persons, objects, and symbols in their immediate environment (Bronfenbrenner, 1977, 1994).

Ecological models have been developed to understand the mechanisms underlying potential interventions intended to change behavior (Bronfenbrenner, 1994). Such models are distinguished by the inclusion of those aspects of the environment and policy which may influence behavior, i.e., instead of assuming that behavior is based solely on individual and social characteristics, ecological models incorporate other influences at many levels. For example, an adapted socioecological model of physical activity (Figure 2.1) underlines five strata of influence, all interconnected: individual (e.g., demographics), interpersonal (e.g., social, cultural),

environmental (e.g., park facilities), regional or national policy (e.g., laws), and global (e.g., the economy) (Bauman et al., 2012). The combination of these factors are expected to influence physical activity.

Consequently, in my work on this dissertation, I was guided by the aforementioned theoretical framework: the socioecological model for physical activity (Bauman et al., 2012; Sallis et al., 2006). From the perspective of this model, the use of parks by and park-based physical activity in children in low-income communities of color must follow a holistic approach, incorporating multiple levels of influence for such behaviors. I used the socioecological model to determine the methods and analyses I used in my dissertation. For example, I employed different tools to assess distinct layers of the socioecological model: survey questionnaires which were focused on individual and interpersonal (e.g., age, gender) characteristics; and, GPS as well as GIS, which were focused on environmental characteristics (e.g., park facilities, locations used by children).

The factors highlighted in the socioecological model, which I used as a theoretical framework to guide my aim of understanding children's use of parks and physical activity in low-income communities of color, are discussed below.



**Figure 2.1. The adapted ecological model of the determinants of physical activity (Bauman et al., 2012).**

### *Individual and Interpersonal determinants of physical activity*

Due to extensive research on individual correlates, interpersonal correlates and determinants of physical activity, the adapted socioecological model suggests that age, gender, and race/ethnicity are evident influencers of activity behavior (Bauman et al., 2012). Although recognizing these factors is important for developing physical activity intervention strategies, we must understand the mechanisms underlying these findings.

One approach to understanding the gendered nature of leisure is through culturally determined expectations and attitudes. This approach focuses on the idea that some activities are deemed appropriate for males or females, specifically, during their leisure time activities (Shaw, 1999). Even though children may not be well defined in their identity at a very young age, male sex had a consistent positive association with physical activity in 4-9 year-olds (Bauman et al., 2012). A review of 54 studies showed boys were more active than girls in 81% of comparisons (Sallis et al., 2000), but there were no distinctions made concerning the environments where

physical activity took place. There are differences between males and females in their choice and intensity of physical activities, but the reasons for this are not necessarily obvious.

A longitudinal study of children 8-12 years of age (n=555) indicated (similar to other reports) that girls were 19% less active than boys, with 9,420 steps per day versus 11,360 steps per day, respectively ( $p < 0.01$ ). Although no causal inference can be made, girls had 18% less cardio-respiratory fitness than boys, 44% less eye-hand coordination, a greater percent body fat, and less self-efficacy, all potential consequences of lower physical activity levels (Telford et al., 2016). Better access, greater investment, and changes in sociocultural norms have been cited as potential places to begin to address the gender gap in physical activity. Sport could also be an opportunity to challenge the cultural norm (The Lancet Public Health, 2019) as the evidence showed that boys were more likely to play extracurricular sports, which protected them against the decline in physical activity which occurs as children age (Telford et al., 2016).

As children become adolescents then young adults, their increasing age has been referred to as a cause for the decrease in physical activity participation (Besenyi et al., 2013; Brooke et al., 2016; Ross et al., 2014). Age as a continuous and changing aspect of the life course brings new responsibilities, life roles, and opportunities that lead to distinct engagement in leisure activities (Kelly, 1999). Physical activity levels frequently decrease over time (Sallis, McKenzie, Elder, & Conway, 1999). Evidence indicates a decline in physical activity levels among children beginning at adolescence (Brooke et al., 2016; Nader et al., 2008). However, researchers have found that children who maintained a good level of physical activity throughout childhood and adolescence had a better chance of becoming active adults (Ross et al., 2014; Telama et al., 2005), supporting the need to develop interventions to help children remain active throughout the lifespan.

Telama et al. (2005) examined repeatedly a cohort of children and adolescents aged 3 to 18 years old and found that being active at ages 9 to 18 predicted a higher level of physical activity as an adult. Younger children have consistently been found to be more active than adolescents. Belcher et al. (2011) used data from the 2003-4 and 2005-6 National Health and Nutrition Examination Survey (NHANES) for youth aged 9-16 years old. Children 6-11 years old were, on average, 58 minutes more active per day than 12-19 year olds (Belcher et al., 2011). Though physical activity declines with age in the leisure domain, researchers have found that adolescents 14-16 years old show an increase in time spent in active transportation (Klinker et al., 2014; Olds et al., 2009). Thus, supporting active behavior as age increases may look different according to the age group being targeted.

Physical activity also varies across youth by racial and ethnic backgrounds, which may be due to social inequalities, for example, in the distribution of recreational facilities (Gordon-Larsen et al., 2006). Access to and availability of physical activity resources both were positively associated with Black adolescents' physical activity, even though participation in physical activity is consistently low, especially for Black girls (Baskin et al., 2015; Sirard et al., 2008). Social support from family and friends is an encouragement for physical activity for a majority of Black boys and girls (Baskin et al., 2015; Lown & Braunschweig, 2008) with most girls perceiving parental reinforcement as more important. Adolescents who perceived higher levels of parental support for physical activity engaged in more minutes of moderate-to-vigorous activity in a sample of majority Black youth (Wilson et al., 2011).

### ***Environmental determinants of physical activity***

In this dissertation, I considered two environmental aspects: the park, as a behavior setting; and park features, as potential facilitators or detractors of physical activity. Roger Barker proposed

the behavior setting theory in the 1950s, suggesting that behavior is dependent on intrapersonal factors as well as individual perceptions of an environment. He also suggested that behavior should be studied in real-life situations, where behavior outcomes could be better predicted *in situ* rather than only estimated based on individuals' personalities (Popov & Chompalov, 2012). Barker noticed through direct observation that behavior settings have clear spatial and temporal boundaries. They are composed of people, physical components, and behavior (Barker, 1976). These settings are ecological units in which the physical environment and the behavior are connected. In the study of Design, this concept of unity is applied, for example, by not attempting to understand a park feature merely as simply the functional part of the outdoor environment but rather as a generalized context for behavior (Cosco et al., 2010), that allows spaces to be used for whatever behavior the user may wish, despite the expectation of what the space is "made for". For my dissertation, I define behavior settings as the play areas in which certain behaviors are encouraged or likely to be observed; for example, playgrounds for free play, courts and fields for sports, open spaces for running. These will be referred to as park features.

Attributes of parks may be associated with physical activity levels and one of my intentions in this dissertation is to identify those potential relationships. Cognitive models of spatial behavior focus on individuals' perceptions and knowledge of the environment; such factors can result in spatial patterns indicating preferences and activity (Madl et al., 2015). These models can help the understanding of how behavior shapes the built environment and how such an environment influences behavior.

### ***Regional, National, and Global determinants of physical activity (Policy)***

Policies at the regional, national, and global levels affect entire populations over extended periods of time, whether directed at the built environment, such as creation or improvement of

existing infrastructure, or aimed at societal-level factors such as crises or natural disasters or social norms (Bauman et al., 2012). The Theory of Social Change proposes an alteration of mechanisms within the social structure, characterized by changes in cultural symbols, rules of behavior, social organizations, or value systems. An approach to social change later developed was called structural functionalism and this theory postulates the existence of certain institutions that determine social behavior (Henderson et al., 2004). Thus, policy and social norms at any level (regional, national, or global) have an advantage in reaching more people for longer terms to implement physical activity inducing norms.

To improve physical activity promotion, policies could incorporate some of the findings concerning the environmental factors associated with active behavior. Abercrombie et al. (2008) assessed the availability of and access to parks and found that more parks were located where child density is higher, indicating a possible positive placement decision based on providing access to children, or families with children choosing to live closer to parks. Although the causal relationship cannot be established, budget allocations that benefit the access and availability of structures for physical activity can be incorporated at the regional level. Such budget allocations could not be put into action without the social context. For instance, regions of the U.S. have been shown to have fewer recreation facilities when there is a predominance of minorities and low-income census tracts (Jones et al., 2015).

At a larger scale, National Physical Activity Plans or Programs have been launched in recent years to promote active behaviors throughout the world. Although these plans are not primarily targeting children, changing the social norm where physical activity is promoted for all can lead to longer-term change. There has been evidence of physical activity benefits, correlates, and determinants in children, but this is still a challenging age group since their cognitive, physical,

and social development are largely expanding during this time of life. We must remain mindful of the needs of each phase of development to better cater to these populations and provide benefits that will last throughout their lifespan.

Acknowledging the distinct factors that may influence a child's decision and opportunity to be physically active is the first step to a better understanding of the use of parks as well as park-based physical activity. Though my dissertation work covers only certain aspects of individual, interpersonal, and environmental determinants of physical activity, its methodology, measurements, and results are a step forward toward exploring the potential to inform park management, design, and future interventions to promote physical activity.

## **CHAPTER 3: A MULTI-METHOD PROTOCOL TO INVESTIGATE PARK-BASED PHYSICAL ACTIVITY IN LOW-INCOME COMMUNITIES OF COLOR**

### **Introduction**

Obesity in youth is an ongoing public health concern affecting increasing numbers of young people across the globe (Kohl et al., 2012; Oreskovic et al., 2015). Childhood obesity can compromise physical and psychosocial development in ways which can accumulate over a lifetime (Ogden et al., 2018). The prevalence of childhood obesity in the U.S. differs by socioeconomic class and racial/ethnic background (Kumanyika, 2017). Social and environmental injustices result in the greatest risk for health disparities in low-income and under-resourced populations (Hales et al., 2017).

The numerous health benefits obtained when children are active at light, moderate, or vigorous intensity include decreased obesity, reduced frequency of cardiometabolic risk factors, improved physical fitness, better bone density, cognitive performance, and mental well-being (Poitras et al., 2016). Seeing that physical activity is one-half of the energy balance equation, the promotion of active behavior is a relevant strategy for addressing the risks associated with obesity in youth.

The World Health Organization recommends that youth accumulate 60 minutes of moderate-to-vigorous physical activity per day, independent of gender, race, ethnicity, or income level (Bull et al., 2020; Piercy et al., 2018). However, a nationally representative sample of children 6-17 years old in the U.S. demonstrated that less than 25% are sufficiently active. There was a significant decrease in meeting the recommendations for physical activity with increasing age, and girls were less active than boys overall (National Physical Activity Plan Alliance, 2018). Additionally, certain demographic groups have a greater likelihood of being physically active due

to social and environmental disparities. For example, Black youth and White youth were found to be more active when compared to Latino youth (Belcher et al., 2011; Harrolle et al., 2013).

Intending to better understand these disparities, the Robert Wood Johnson Foundation (RWJF) developed a Culture of Health framework to describe a comprehensive approach to providing equitable conditions for population health (Robert Wood Johnson Foundation, 2016). In response to those needs presented by the RWJF, the PARC developed a research agenda that addresses youth physical inactivity, prioritizing those children at higher risk. A matrix of potential research questions was developed to identify the priorities in promoting physical activity across race, cultural, and economic groups (Botchwey et al., 2018). The PARC<sup>3</sup> Study is one of the arms of this initiative, and is focused on children's physical activities in parks located in low-income communities with predominantly Asian, Black, and Latino populations.

### ***Parks and Physical Activity Measurement***

Several studies describing the characteristics of playgrounds and their potential associations with physical activity have used observational or self-reported measurements (Azlina & Zulkiflee, 2012; Czalczyńska-Podolska, 2014). Direct observations can identify not only the number but also the type of activities and has demonstrated a high reliability even when other variables are included such as age, gender, and race/ethnicity (Bocarro et al., 2009; Marquet, Hipp, et al., 2019; McKenzie et al., 2006). Importantly, however, direct observations are dependent on extensive training and several hours of data collection (Cohen et al., 2011).

As an emerging method in the last decade, the use of electronic devices such as accelerometers and GPS has demonstrated accuracy when collecting human behavior data (Doherty et al., 2014; Schipperijn et al., 2014). The potential to incorporate activity intensity and

geographic location provides a better set of resources with which to study physical activity and the environment. Thus, the PARC<sup>3</sup> study used a combination of methods to better understand physical activity behavior, including the use of systematic observations and devices to capture movement and location. In this paper, I describe the overall framework of the PARC<sup>3</sup> Study, a multi-method, multi-site study of parks in low-income communities of color.

In partnership with the PARC and funding from the RWJF, the PARC<sup>3</sup> Study was designed to examine the patterns of park use among children from different racial and ethnic groups in low-income neighborhoods. PARC<sup>3</sup> is a cross-sectional study that uses the socio-ecological model for active living as a theoretical framework (Bauman et al., 2012). The three primary aims of the study researchers were:

- 1) To identify social, environmental, programmatic, and spatial attributes of parks associated with parental decisions about their children's use of neighborhood parks. Research question: Do parents of different racial/ethnic groups report unique preferences in park attributes and space for their children?

- 2) To compare how children from different racial and ethnic groups use parks and park-based recreation facilities. Research question: Do use of park zones and facilities, time spent in different park zones, and levels of park-based physical activity differ across children of different races and ethnicities?

- 3) To determine the extent to which specific park characteristics, features, programs, and social contexts are associated with children's physical activity during park visits and decisions to visit parks. Research question: Does availability and quality of park attributes interact with parental decisions to visit parks as well as children's time and physical activity expenditure differences?

## **Methods**

To address these aims, the study was conducted with three methodological components which integrated direct observations, monitoring, and household surveys. Direct observations included observations of park use and physical activity, characteristics of areas for physical activity, presence and quality of park infrastructure, and neighborhood built environment characteristics. Monitoring involved the use of monitoring devices (GPS and accelerometer) to identify physical activity levels and geographic locations of 5-10-year-old park users along with an in-park survey with a parent or caregiver while the child was monitored. Household surveys comprised of questionnaires were delivered electronically to parents of children 5-10 years old. Each methodological component had its approval from the North Carolina State University Institutional Review Board.

### ***Study setting and population***

Each individual project of the broader, four project PARC focused on a specific region of the U.S. as well as youth living in low-income communities of color. PARC<sup>3</sup> was tasked with understanding youth park-based physical activity primarily in low-income Asian, Black, and Latino neighborhoods. Given limits related to the number of Asian American and Latin American youth resident in Raleigh and Durham, North Carolina, colleagues in New York City were engaged early in the project to include this city as a second study setting. Thus, the study took place in two regions of the U.S.: New York City, NY (NYC), and Raleigh and Durham, NC (RDU). In the northeast, NYC comprises a major commercial, financial, and cultural center, with a population estimated at more than 8 million in 2018, with immigration being a great contributor to diversity (NYC Planning, 2019). In the southeast, the cities of RDU comprise a population of almost two million and are known as two of the three corners of the Research Triangle, home to numerous

technology companies and enterprises, as well as universities, attracting diverse populations contributing to the heterogeneity of the region (Demographics research group, University of Virginia, 2019).

A sample of 20 parks located in low-income neighborhoods was selected per region (n=40 parks total). In NYC, neighborhoods with a majority Asian and Latino population were selected. In RDU the neighborhoods were a majority Black and Latino. Data collection took place from May through August of 2017 in NYC and the same months of 2018 in RDU. An associated national household survey was open from September to November 2018.

### ***Park selection***

GIS data were acquired for both NYC and RDU, including park boundaries, acreage, and amenities. The final eligible park sample included only those with a playground and a type of sports facility such as courts or fields. Demographics per block group from the American Community Survey (ACS) 2014 (U.S. Census Bureau, 2014) were used to identify population counts per race/ethnicity (White, Black, Latino, Asian), as well as age (0 to 14 years old). Estimated median household income followed the U.S. Department of Housing and Urban Development (U.S. Department of Housing and Urban Development, 2017) recommendations, with block groups below 80% of the county median considered as low-income. Table 3.1 shows income thresholds for each county included in the study setting.

**Table 3.1. Description of low-income threshold based on counties median household income in U.S. dollars.**

County	2015 Median Household Income (\$)	80% of Median Household Income (\$)
New York City		
Bronx County (Bronx)	35,176	28,141
Kings County (Brooklyn)	51,141	40,913
New York County (Manhattan)	75,575	60,460
Queens County (Queens)	60,422	48,337
North Carolina		
Wake County (Raleigh)	70,533	56,426
Durham County (Durham)	53,495	42,796

Network buffers were created around the parks; these buffers extended outwards for ¼ mile in NYC and ½ mile in RDU due to population density and street/pedestrian infrastructure, which are common spatial buffers in exposure studies (James et al., 2014). A network buffer uses the street network radiating from the park entrances, at the distances noted. Each Census block group intersecting a park network buffer was summarized for the number of children per race/ethnic group and the averaged median household income was calculated. Later, a dissolved set of block groups was spatially joined to the park. This allowed the creation of a dataset per park including surrounding neighborhood demographics, estimated number of children per race/ethnicity, median household income, and park characteristics (e.g., size, address). Parks meeting the following criteria were retained as potential sampling areas for this study: 1) including at least one playground and court/field on which children would be likely to play; 2) the average median household income of Census block groups within the request distance of the park was 80% or less of the county median household income. These potential sample parks were then ranked by the number of youth living within the same Census block group areas. In NYC, we focused on youth the Census identified as Asian or Latino, and in RDU we focused on youth the Census identified as Black or Latino. The 30 parks with the most youth living around them were then shared as a list with the NYC, Raleigh, and Durham City Parks Departments. Some parks were recommended as not suitable for observation due to construction plans, and others overlapped with other research

projects in NYC (Huang et al., 2016). Finally, we visited each remaining park to ensure the mandatory park features were present (at least one playground set and one court or field). Finally, a total of 10 parks in majority Latino neighborhoods and 10 parks in majority Asian neighborhoods were selected in NYC, and 15 parks in majority Black neighborhoods and 5 parks in majority Latino neighborhoods were selected in RDU.

As we visited each park, we also determined the areas of interest within each park for direct observations (target areas), which we captured with a Trimble GeoXT Handheld GPS receiver. The boundaries for all areas with the potential for activity were geolocated, named, and numbered. These areas included playground sets, courts, fields, swing sets, splash pads, open green spaces, and others (Figure 3.1).



**Figure 3.1 Example of map with target areas within a park, used for direct observations and monitoring. People's Park in the Bronx, New York City, NY.**

To prepare for our monitoring component, wearable GPS receivers were brought to the parks for testing. Since GPS accuracy can be affected by the type of environment surrounding the parks' locations (Schipperijn et al., 2014), there was special concern in New York City where the landscape is formed by mostly tall dense buildings blocking or reflecting satellite signals. The GPS data were loaded into ArcGIS and the GPS points within park boundaries were assessed for accuracy (e.g., number of points falling within park boundaries) and the selection of parks GPS/accelerometer for monitoring.

### ***Direct Observations***

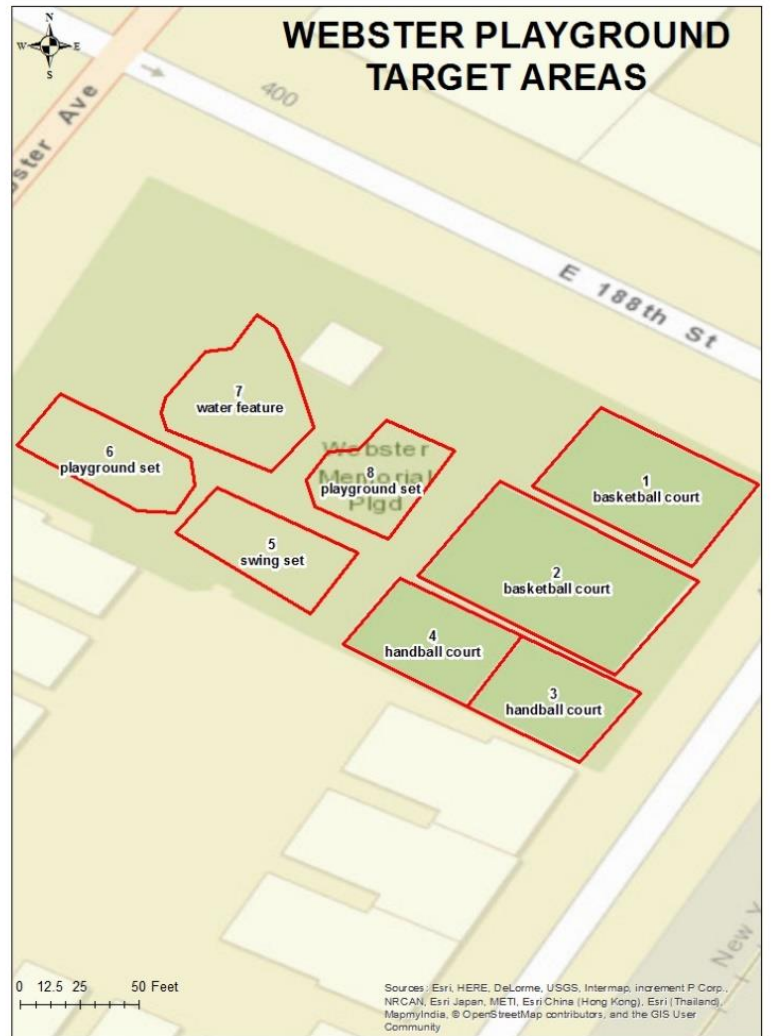
All 40 selected parks and street segments immediately connecting to the parks were assessed by direct observation. To assess park use and physical activity, we used the SOPARC approach (McKenzie et al., 2006). For assessment of park characteristics and quality, the electronic Community Park Audit Tool (eCPAT) was used (Besenyi et al., 2016; Kaczynski et al., 2012). Finally, street segments connecting to the parks were audited via the Active Neighborhood Checklist (ANC) (Hoehner et al., 2007.). The direct observation portion was exempt from IRB approval as it qualified as a minimal risk and did not require interaction with participants.

### **System for Observing Play and Recreation in Communities (SOPARC)**

The SOPARC protocol (McKenzie et al., 2006) was developed to identify in a momentary scan (or a combination of them) the condition, use, and physical activity levels in areas of interest. It provides objective data on the use of spaces, including physical activity in predetermined target areas. We used SOPARC to determine park use and physical activity intensities, park characteristics, and park user sociodemographics. The original protocol allows the momentary

assessment of those areas and includes accessibility, usability, presence of equipment, organization of activities, presence of staff or parents, shade cover, primary activities, and number of people using the locations identified by gender, age, race/ethnicity and level of physical activity, separately. The original tally mark formatting of SOPARC only allowed gender to be associated with age group and physical activity level. We therefore modified the original form and protocol to denote gender, age group, race/ethnicity, and physical activity levels of each person observed.

Per SOPARC protocol, observers were provided with park maps. They moved around the previously determined target areas (Figure 3.2) starting at target area number one, scanning for females and the different age groups first (i.e., female 0-4; female 5-10; female 11-19, etc.). Next, they scanned for perceived race/ethnicity and physical activity levels of females in the target area. They then repeated this sequence for males.



Target areas: 8 (2 basketball courts, 3 handball courts, 1 swing set, 1 water feature, 2 playground sets)

**Figure 3.2. Example of a map with sequence target areas visited for direct observations with SOPARC. Webster Playground, NYC (2017).**

SOPARC was conducted on two random non-consecutive weekdays and both weekend days, for one-hour periods (beginning at 3pm, 4:30pm, and 6pm during spring; 10am and 6pm during summer) at each of the 40 parks. Times differed by season due to the time at which schools released their students during spring and high temperatures in summer. The target areas were assessed every 15 minutes within each hour (four rounds per period). This accounted for 4,725 observations completed simultaneously by two independent observers, which allowed us to

perform reliability checks (Marquet, Hipp, et al., 2019). Table 3.2 shows the key measures obtained from the use of SOPARC.

**Table 3.2 SOPARC key measures, available for each target area.**

Themes	Variables	Scale	References
Conditions of the target area	Accessibility, Supervision,	Yes	(McKenzie et al., 2006)
	Equipment, Usability, Dark, Empty	No	
	Organization – Formal or informal activity, Shade cover, Adult role	Yes	(Bocarro et al., 2009)
		No	
Participants	Gender counts	Female	(McKenzie et al., 2006)
	Physical activity level counts	Male	
		Sedentary	(McKenzie et al., 2006)
		Moderate	
Age counts	Perceived race/ethnicity counts	Vigorous	
		Children 0-4yo / 5-10yo	
		Teen	PARC <sup>3</sup>
		Adult	
		Senior	
		White	
		Black	
Asian	PARC <sup>3</sup>		
Latino			
	Other/Unsure		

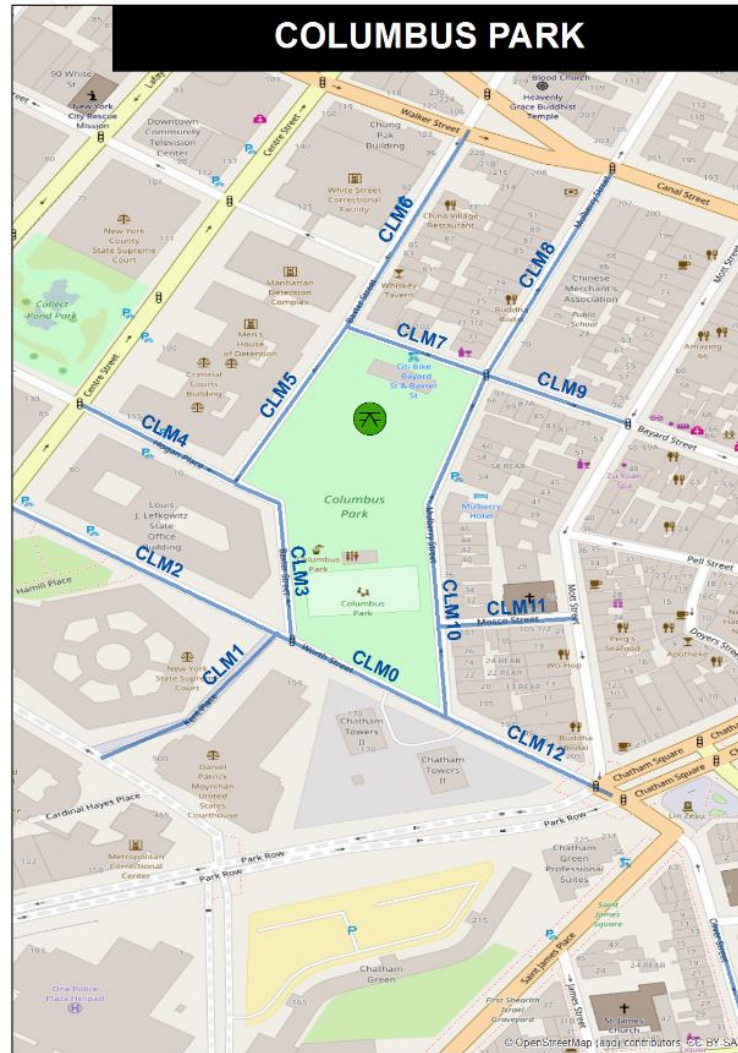
### Community Park Audit Tool (CPAT)

The CPAT (Kaczynski et al., 2012) is a reliable tool used to assess the presence and quality of features in parks. The tool includes items regarding activity spaces, facilities such as restrooms and water fountains, available benches, and the trashcans. There are four sections in the collection form: park information, access and surrounding neighborhood, park activity areas, and park quality and safety. The CPAT protocol indicates the observer should walk throughout the park and take note on the paper form of the number of items as well as qualify them according to their characteristics (e.g., mixed colors of paint/material in a playground set). The original CPAT protocol was used in NYC but, due to an ongoing project that was collecting data in RDU (Kaczynski et al., 2016), the we used the electronic version (eCPAT) (Besenyi et al., 2016) to

assess the parks in North Carolina. There are no significant differences between the original paper form and the electronic version of this audit tool (Kaczynski et al., 2012).

#### Active Neighborhood Checklist (ANC)

The ANC was used to assess street-level features of the neighborhood surrounding the selected parks (Hoehner et al., 2007). This tool is used to obtain data concerning five general areas: land use, public transit stops, street characteristics, quality of the environment for a pedestrian, and places to walk and cycle. All streets immediately connecting to the parks were mapped and segments were numbered (Figure 3.3), totaling 331 segments for evaluation in the two cities (NYC=196; RDU=135).



**Figure 3.3. Example of map with street segments surrounding parks for assessment. Columbus Park in New York City, NY.**

### ***Monitoring*** Park selection

Our monitoring in parks was intended to acquire movement (via an accelerometer) and spatial location (GPS receiver) of children 5-10 years old during a park visit. Not all 40 parks were monitored due to logistics (project timeline) and resources (number of monitoring devices available). Six of the 20 parks per region were selected for monitoring to identify levels of physical activity across park zones. The initial sample size was 30 participants per each of the six parks in

each city, with a stated one-day sample of 15 minutes. Each park was to be visited twice, once per season.

As previously stated, GPS points were gathered inside parks during our initial scouting. The data was loaded into ArcGIS and the points within park boundaries were assessed. Parks with more data points within the GIS park boundaries were considered preferred for monitoring. The final selection criteria for parks considered: 1) the proportion of accurate GPS points acquired during the scouting trip; 2) the number of neighborhood parks proportional to the full park sample; 3) the number of children potentially 5-10 years old observed during our initial observations with SOPARC; and, 4) the safety of the park as perceived by team members. Finally, six parks were selected in each city. NY: three parks each in majority Asian and majority Latino neighborhoods; and, NC: four parks in majority Black neighborhoods and two parks in majority Latino neighborhoods.

### Monitoring Procedures

Due to travel of the NC research team to all parks for monitoring and to minimize, to the extent possible, the confounding impact of weather, two separate parks were visited each day for monitoring recruitments. Two research staff members traveled to each park so that one researcher could assist with monitoring equipment and the other with parent/guardian surveys. Each park was visited at least twice, once in the spring and once in the summer, alternating weekdays and weekend days.

Fifteen elastic belts with an accelerometer (Actigraph GT3X+ at 30Hz capture rate) and a GPS (QStarz BT-1000XT at 1-second capture rate) device were brought to each of the parks and one was worn by each participant at any time between 10am and 7pm, for a minimum of 15

minutes. Before they could enrol their family in the study, the parent had to state the family intended to remain in the park for at least an additional 15 minutes.

To recruit participants, researchers moved throughout the target areas looking for children perceived to be 5-10 years old with a parent/guardian nearby; the researchers would move from one target area to another in the opposite order (higher target area number to lower) from that which had been used for direct observation. The parent/guardian was approached, the study presented, and the consent form was provided so that they could read it on their own before agreeing to participate. We required a parent/guardian to sign the Informed Consent Form before the beginning of participation. The child was asked for verbal assent and both parent/guardian and child initialed the consent form to take part in the study. Informed Consent Forms were available in Simplified Chinese and Spanish in addition to English. Participants were offered a \$10 gift card as an incentive for participating.

After parental consent and child assent, the child was fitted with the belt containing the accelerometer and GPS devices. Parents were asked to fit the belt and researchers only fitted the belt if parents/guardians asked for assistance. After the belt was securely on the child and the devices were ensured to be activated, the child was free to play while the parent/guardian was invited to respond to a tablet-based survey that included items related to park visits, frequency of park use, play area preferences, and demographics (Table 3.3).

**Table 3.3 Park feature use and park-based physical activity measurement sources, outputs, and references for monitoring children 5-10 years old and a parent/guardian in low-income neighborhood parks.**

<b>Theme</b>	<b>Variables/Sources</b>	<b>Response scale/Output</b>	<b>References</b>
Physical activity	Accelerometer counts / Actigraph GT3X+ at 30Hz	Cut-points for children (15-second epochs) Sedentary (0-25) Light (26-573) Moderate (574-1002) Vigorous (1002+)	(Evenson et al., 2008)
Geographic location	Longitude and latitude / QStarz BT1000-XT at a 1-second capture rate	Location points within park boundaries Location points within park features	
Park visit	Decision to come to the park, transport to the park, frequency of park use, length of park use, activities in the park		(Payne et al., 2005)
Perceived safety	How safe did you feel in the park	Not safe at all Not very safe Safe Very safe	(Cohen et al., 2006)
Social cohesion	People get along, share same values, can be trusted, are willing to help	Strongly disagree Somewhat disagree Somewhat agree Strongly Agree	
Parental park preferences	In an ideal park in your neighborhood, what would you want for your children?	Open question	
Parents' demographics	Gender, age, race/ethnicity, relationship with the child		
Children' demographics	Gender, age, race/ethnicity		

### ***Household Survey***

To address park use preferences and constraints, a household survey was planned to reach park users as well as non-users residing in the neighborhoods surrounding the previously selected parks. The original goal was to collect the household survey data via telephone, concurrent with the other data collection efforts for the project. The expected sample size was 1200 families. The initial process for recruitment included distributing postcards with a QR code and URL so residents in the neighborhoods surrounding the previously selected parks could respond to the survey online.

### **Procedures**

NuStat® was hired to distribute the surveys over the phone. However, that strategy did not provide an acceptable response rate, which resulted in a mutual agreement on our part as well as

NuStat's part to cancel the contract. We next distributed the survey to a panel of respondents whose names we purchased from QualtricsXM. The initial geographic location of participants (i.e., participants must live in NYC or RDU) was discarded in favor of surveying a sample of low-income families with children 5-10 years old across the U.S.. Low-income was considered to be at or below 80% of the federal median household income, i.e., less than \$42,786. Respondents self-identifying as non-White were oversampled to achieve at least 80% of total participants. Parents and guardians of at least one child 5-10 years old were included in the sample. Data was collected over 50 days, from September to November 2018. Although it is not possible to determine response rate for the Qualtrics panel (the denominator is impossible to estimate), the company assures thorough quality control. The median response time was eight minutes in a final sample of 1,611 participants. All participants responded to eligibility determination screening questions. Screening questions began with "In what state do you reside?". The states of North Carolina and New York and the ZIP codes™ in which the 40 study parks were located were oversampled. The online survey contained questions regarding parents' perceptions of neighborhood walkability, safety, as well as social capital, places for youth physical activity, and park visitation behavior (Table 3.4).

**Table 3.4 Household survey key measures**

Theme	Variables	Response scale	References
Park visit	Frequency, length of park stay, company, decision to go, use of park features, distance to park		(Payne et al., 2005)
Barriers for park use	Time, programming, facilities, cost, safety, health, distance, dislike parks, weather, crowds	Yes No	(Carlson et al., 2010)
Satisfaction with the park		Not at all satisfied Somewhat satisfied Extremely satisfied	(Moore et al., 2009)
Social cohesion	People get along, share same values, can be trusted, are willing to help	Strongly disagree Somewhat disagree Somewhat agree Strongly Agree	
Neighborhood perceptions	Street connectivity, traffic, safety from crime	Strongly disagree Somewhat disagree Somewhat agree Strongly Agree	(Cerin et al., 2013)
Other places for physical activity	Playground availability, frequency of activity in other places		
Child's demographics	Gender, age		
Parent's demographics	Gender, age, height, weight, race/ethnicity, education		
Household demographics	Number of adults, number of youth, primary decision maker, income, length of residence, ownership, family composition		(Fan et al., 2012)

## Analysis

We employed a cross-sectional design which restricts our analysis to non-causal relationships. General descriptive statistics (mean, median, standard deviation, interquartile range, minimum and maximum, proportion) were calculated for all study variables.

## Discussion

We sought to examine the patterns of park use among children from different racial and ethnic groups in low-income neighborhoods. Although cross-sectional in design, as is the majority of research on parks and health outcomes (Lachowycz & Jones, 2013; Zhang et al., 2018), our multi-site, multi-method study contained a well-rounded approach to research in parks, especially with children. Most researchers in this area have used only self-reported measures of both the

environment and physical activity. To our knowledge, we are the first to recruit participants within parks, utilizing a combination of objective measures and self-report. There is a lack of examinations of children's use of parks in under-resourced neighborhoods and this constitutes an important step to understanding the use of and activity in parks.

We selected the two cities whose parks we examined based on those populations in which we and our funder were interested. By only including parks in low-income neighborhoods we lack the potential comparison with high-income neighborhoods and the relationship between our outcomes and income levels cannot be established. Our analytical approaches must also consider whether the data from NYC and RDU can be used in combination or if samples will be limited to each region, neighborhood, or park. Although our multi-method approach is innovative and addresses several aspects of data collection in both health and the environment, the number of potential units of analysis can be challenging. Regions, neighborhoods, parks, target areas, children in parks, parents of children in parks, are all interrelated and nested.

### ***Direct Observation/SOPARC***

Direct observations of target areas were scheduled on the number of days of the week and periods of the day recommended by other studies reported in the literature (Evenson et al., 2016). As our focus was children 5-10 years old, school day data collection efforts were limited to observations obtained in the parks during the afternoon (after 3pm) so children could be observed. One positive aspect of this limitation is that our observation data may help identify when indeed children are coming to the park after a school day.

Although our observers were trained and we tested their reliability, our observational data relies on their knowledge, experience, and perceptions of the observed variables. Our

implementation of the SOPARC approach required our observers to perceive gender, age group, race/ethnicity, and physical activity levels. These perceptions can be challenging, problematic, and biased. This is especially true for race/ethnicity and age groups, and even more for those identifiers when combined (Marquet, Hipp, et al., 2019). Further, social inequalities may be exacerbated due to the fact that Black children, especially boys, are often perceived to be older than their actual chronological age (Goff et al., 2014).

The combination of variables and the scanning procedures required of our observers can also be a challenge when conducting observations. Scans are momentary in nature and, even if a very intense activity is being performed in a certain target area, the moment in which children are observed might be of a lesser intensity than the overall activity (e.g., a foul shot during a basketball game). SOPARC protocol requires target areas to be established where scans are conducted, therefore, only those pre-selected and well-delimited areas are observed and the overall context of the spaces is not taken into consideration.

### ***Monitoring***

Children were monitored in 12 of the 40 total parks we selected. As the goal was to have a sample of at least 30 participants per park, per season, the selection for the monitoring phase was intentional and aimed at parks with a higher density of users and which had better GPS reception. This alone is an important limitation since it has been shown that children tend to be more active when there are other children in the playground with them (Boonzajer Flaes et al., 2016). The short minimum period of data collection (15 minutes) could also suffer from children's reactivity to the use of the devices, i.e., children could be more active than they normally would knowing they were being monitored. Dössegger et al. (2014) suggest participants should have a familiarization period

to avoid reactivity, but that is based on seven-day monitoring. As we performe data collection activities for each child over a much shorter period, other alternatives to reducing the potential reactivity effect could be increasing wear time and eliminating the first few minutes to avoid influencing results.

The use of GPS receivers in building-dense cities like NYC could also limit the quality of data we obtained during park visits. We avoided this specific limitation by selecting parks where we had previously tested the strength of reception of our devices , allowing for the identification of strong satellite signals and removing parks with poor reception. When processing the data resulting from in-park monitoring, other important decisions must be made, such as cut-points for physical activity levels using accelerometers. Researchers have tested different cut-points and found those selected can have a great influence on the results for physical activity in children (Mota et al., 2007).

As the device wearing period was limited and the intention was to capture as much of the physical activity and locations as possible, the raw data was processed into 5-second epochs to allow better identification of the places in the park where children were. Only one report was found the authors of which used and suggested a cut-point for hip-worn accelerometer data in children in our age group. This is a limitation not only for our results but generally in research with activity monitors, especially with children where the placement of devices and cut-points are very few and don't always agree (McCrorie et al., 2014). Machine-learning has also been used recently to try and identify physical activity intensity and type based on raw acceleration data, independently from the setting where activities occur (Farrahi et al., 2018). The use of accelerometers and GPS devices solely to collect children's data in parks, to date, has not been reported. The use of playgrounds, however, has been documented in children 2-5 years old and within schools

(Andersen et al., 2015; Clevenger et al., 2020). Thus, comparability to other studies may be an issue. We hope that the challenges we faced and the opportunities we fostered may be used to improve future free-living assessments of physical activity.

### *Surveys*

Online surveys have been discussed for over two decades as potential substitutes for in-person methods (Couper, 2000). Though part of the argument for using electronic surveys is to have more responses at lower costs, this is not always the case. We used a Qualtrics panel. The use of a survey distributed to a national sample allowed us to gather information on potential non-park users. As all other phases of our study were conducted in parks, those who were not in those locations were unable to participate. The global reach potential of online surveys is a strong advantage of this method (Evans & Mathur, 2018). We limited the data collection to participants residing in the U.S. through a screening process. By including the non-park users we can better understand what may be some of the barriers to park use and develop strategies to attract new park users.

### *Challenges and Opportunities*

The combination of methods and criteria for selection of locations and participants enabled us to gather a great amount of data of different dimensions and interests, and will certainly help us to answer many questions concerning children's use of parks and park-based physical activity in low-income communities of color. Future analysis should focus on describing park use and physical activity from both observational and monitoring datasets. Additionally, there is an opportunity to find the intersection between these methods. The challenges and opportunities

inherent in such work allow the scientific community to rethink strategies for data collection, data processing, and data analysis, leading to better research.

## **CHAPTER 4: YOUTH USE OF PARK FEATURES AND PHYSICAL ACTIVITY IN DIVERSE, LOW-INCOME NEIGHBORHOOD PARKS**

### **Introduction**

Obesity is a public health concern across the globe, specifically in youth (Kohl et al., 2012; Oreskovic et al., 2015). Almost one third of young people in the U.S. is overweight or obese. Low-income youth from historically under-resourced populations have a higher risk of obesity due to social and environmental disparities (Ogden et al., 2018). Daily physical activity is recommended to help ensure children grow up at a healthy weight (Piercy & Troiano, 2018) but fewer than 25% of American children 6-17 years old are sufficiently active (National Physical Activity Plan Alliance, 2018).

To increase physical activity, access to parks has been studied as a promising alternative (Bedimo-Rung et al., 2005; Kaczynski et al., 2008). Parks are free spaces that can promote healthy behaviors and an average of 30% of observed park users are children 0-12 years old, especially in low-income neighborhoods (Camargo et al., 2018; Evenson et al., 2016; Joseph & Maddock, 2016). Researchers have demonstrated that children are more active than others when in parks (Kaczynski et al., 2011; Roemmich et al., 2014). When children were investigated in the after-school period, for example, their odds of performing MVPA while in greenspaces were more than five times higher than if they were indoors (Wheeler et al., 2010). To date, however, there have been relatively few evaluations of park-based physical activity in low-income communities of color. A more detailed understanding of use of space and features within parks in low-income communities of color may inform park design and programming thereby increasing park use and park-based physical activity.

The numerous health benefits of active behavior among youth can be extended to adulthood (Ross et al., 2014). Decreased cardio metabolic risk factors, decreased adiposity and obesity, improved physical fitness, better bone density, enhanced cognitive performance, and enriched mental well-being are expected when children are active at light, moderate or vigorous intensity (Poitras et al., 2016). However, a surveillance study indicated that only 42% of children 6-11 years old met the recommended 60 minutes per day of MVPA (Bull et al., 2020; National Physical Activity Plan Alliance, 2018).

Beyond the presence of parks in a neighborhood, the features (in addition to the simple green space provided) within a park are important in supporting active behavior (Bancroft et al., 2015). In the Southeastern U.S., Floyd et al. (2011) observed variation in youth park-based physical activity by different park areas. These areas were features that are typically present within parks and were observed mostly occupied by youth: playgrounds, open spaces, picnic areas, sports fields, and courts (Floyd et al., 2011). There is evidence to support the concept that features within parks have the potential to address some of the inequalities in physical activity. Play equipment, water play areas, trees, and shade encouraged park visitors among youth in Australia (Veitch et al., 2021). Girls were more likely to be in playgrounds in the U.S. (Floyd et al., 2011; Loukaitou-Sideris & Sideris, 2010). Loukaitou-Sideris and Sideris (2010) mostly observed Latino youth in soccer fields, while Black and Asian youth were more likely to be in basketball courts. Understanding the preferences of a diversity of youth may better inform park design and thereby optimize physical activity.

Given the benefits of parks for youth physical activity, it is imperative to identify specific, modifiable features within the parks that support moderate-to-vigorous levels of physical activity. We aimed to describe youth use of features in parks within diverse low-income neighborhoods by

gender, age, race/ethnicity, physical activity levels, and temporal characteristics. Specifically, we address the use of park feature types (e.g., playground set, splash pads, courts) in 40 neighborhood parks. For each neighborhood grouping, we analyzed the proportion of users in each of the feature types per each of the following characteristics: (1) demographics (age, gender, race/ethnicity); (2) physical activity levels (sedentary, moderate, vigorous); and, (3) temporal elements (time of the day, day of the week, season).

## **Methods**

### ***Study Settings and Sampling***

Part of the PARC (Botchwey et al., 2018), the PARC<sup>3</sup> study was intended to understand park use and physical activity in low-income, primarily non-White neighborhood parks (Huang et al., 2020; Marquet et al., 2019; Marquet et al., 2019; Ogletree et al., 2020). Three cities were chosen in two regions of the U.S.: New York City (NYC, in the state of New York [NY]), Raleigh (in the state of North Carolina [NC]), and Durham (NC). Raleigh and Durham were considered as one geographic region (NC) to guarantee the intended number of parks and diversity. A sample of 40 parks (20 per region) was selected based on median household income, demographics per block groups (majority non-White block groups), and the presence of a playground and a sports court or field. Income data were identified through Census block groups, which we required to have a median household income below 80% of the county median to be considered as low-income and included in the selection (U.S. Department of Housing and Urban Development, 2017). Demographics per block groups were identified via the 2014 American Community Survey (ACS) (U.S. Census Bureau, 2014) and were determined by the count per race/ethnicity (White, Black, Asian, and Latino) and age (0-14 years old). GIS data from the three cities included park boundaries or centroids and the amenities offered by each park, allowing the identification of the

requisite park feature types. In NYC, the 20 parks were in majority Asian neighborhoods (n=10) and majority Latino neighborhoods (n=10). In NC, parks were in majority Black neighborhoods (n=15) and majority Latino neighborhoods (n=5).

### ***Data Collection***

SOPARC is a protocol that allows observers to count the number of users by predetermined characteristics during a scan of an activity area. The observer can use the tool either via a pencil and paper or an iPad application (McKenzie et al., 2006; Santos et al., 2016). To guarantee each individual observed could have all variables attributed to themselves, we chose to use pencil and paper together with a modified SOPARC form (Appendix A). The adaptations included anchoring by gender and age and creating 10 scans per sheet; the observers then recorded perceived race/ethnicity and physical activity level of each park user within target area boundaries (see Appendix A). Following our modified SOPARC protocol, target areas were pre-determined for observation, each of which included features that could be used for physical activity (n=341; average of 8.5 per park), including baseball fields, soccer fields, basketball courts, handball courts, tennis courts, playground sets, swing sets, games painted on the ground (e.g., hopscotch and foursquare), open green spaces, and splash pads. SOPARC target areas were further collapsed into the following feature types: ball courts (all hard courts except basketball, e.g., handball), ball fields (grass or synthetic fields including soccer and baseball), basketball courts, games, open spaces, playground sets, swing sets, and splash pads. We considered the feature types the primary environmental characteristic.

Direct observations were conducted in the 40 parks, scanning each area from left to right. Every target area was observed in four rounds – one scan every 15 minutes – during one-hour

observation periods. The periods with two or more rounds were the only periods considered valid hours; 80% of hourly periods had four complete rounds. There were 2,718 completed, valid observation hours in NY and 3,163 in NC. Data were obtained during the spring and summer of 2017-2018 across different times of the day (10 am, 3:30 pm, 4:30 pm, 6 pm) and days of the week (weekdays and weekends). We had trained a team of 20 research assistants across the two regions in our modified SOPARC protocol and required them to accumulate several practice hours (>10h) for familiarization with the form and to standardize the measurements. Overall reliability was considered good for NY (ICC=0.94, 75.0% agreement) and NC (ICC=0.94, 82.5% agreement). Detailed reliability statistics can be found elsewhere (Marquet et al., 2019).

### *Measures*

We categorized the perceived demographics of park users by gender (female, male), age (child 0-4 years old, child 5-10 years old, adolescents 11-19 years old), and race/ethnicity groups (Asian, Black, Latino, White, Other/Uncertain). Race/ethnicity was re-categorized for analysis by combining the White and the Other/Uncertain groups because together they represented less than 6% of all children observed. In NC, no Asian children were observed across the 20 parks.

Physical activity was determined by the perceived activity intensity engaged in by children and youth at the time of the momentary scan. “Sedentary activity” included sitting, lying down, and standing still. “Moderate activity” comprised any movement, including a mere change in a standing position while pushing a swing as well as walking (not running or jogging). “Vigorous activity” was defined as movement which would cause a child to breathe heavier than while walking, such as actively playing a sport (e.g., running, jumping).

The temporal categorization of a child's use of park features was determined by the time of the day during which they were observed, i.e., either time of day (10-11 am, 3-4 pm, 4:30-5:30 pm, and 6-7 pm), day of the week (weekday and weekend day), or season (spring and summer). The time of day varied according to the seasons; spring times included afternoon and evening times to capture school times, while summer considered morning and evening. We further combined for purposes of analysis time of day categories of 3-4 pm and 4:30-5:30 pm into one variable labeled Afternoon, 10-11am into a second variable called Morning, and 6-7pm was combined to form a third variable, Evening.

### *Analysis and outcomes*

#### Demographics and park-based physical activity

Descriptive statistics were used to determine the frequency and proportions of youth by age group, gender, race/ethnicity, and level of physical activity across each of the feature types. In these analyses, park users were the unit of analysis. This approach eliminated the zero counts and represents the use of features by the children observed. Chi-squared tests were used to test independence and answer the question: "Is there a statistically significant relationship between use of feature, demographics, and physical activity levels?" Our null hypothesis was that the variables were independent and there were no statistically significant differences in the use of park features. If the p-values for the Linear-by-Linear Association coefficient were less than 0.05 (for an alpha level associated with a 95% confidence level), then the null hypothesis was rejected, and the variables were considered dependent or statistically related. Pairwise comparisons were analyzed using a post-hoc Z-test of two proportions to identify which feature types were different from each other in their proportional use stratified by gender, age, race/ethnicity, and physical activity level.

All tests were performed per neighborhood type (majority Asian and Latino neighborhoods in NY and majority Black and Latino neighborhoods in NC) independently and results presented as such. All analyses were performed in IBM SPSS 25.0 (2018).

#### Temporal patterns of park use

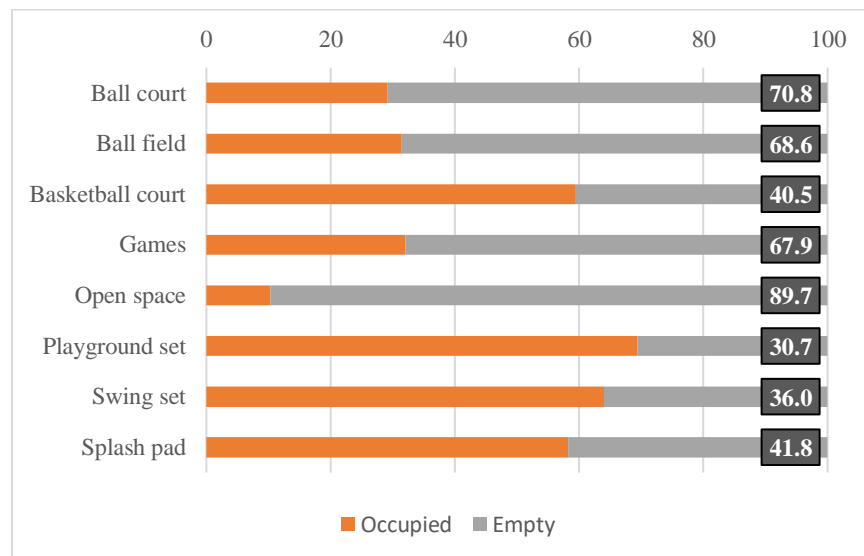
We used a central tendency measure to describe the use of feature types by day of the week, time of the day, and season. These analyses used the feature types as the unit of analysis. We used the mean and standard deviation because the temporal patterns were dependent on the number of scans, which varied according to season. We used non-parametric Kruskal-Wallis tests for our analysis of variance due to lack of normality, with almost 50% of the data being zeros or empty spaces per momentary scan for youth. Additionally, we calculated the delta percentage ( $\Delta$  %) only for variables with statistical significance to determine the relative difference between them via the equation  $[(Na - Nb)/Nb]*100$ , where  $Na$  = final value and  $Nb$  = initial value. Significance values were adjusted by the Bonferroni correction for multiple tests and the confidence interval was kept at 95%. All analyses were performed in IBM SPSS 25.0 (2018).

## Results

The distribution of observation periods by feature types within neighborhoods is shown in Figure 4.1. An average of 8.5 activity features was present in each park. For the 341 features there was a total (overall) of 22,267 rounds of observation (every 15 minutes) completed, or an average of 65.3 observations per individual feature area. These rounds not balanced, with 9,940 in NY and 12,327 in NC. The 22,267 rounds of observation represent 5,881 hours of observation, or 17 hours per feature area. In total, 41,410 youth were observed during these 5,881 hours of observation. The

distribution of observation periods per feature type was similar per period of the day, day of the week, and season. All feature types were mostly observed being occupied in the evening (40.8%), during weekdays (53.7%), and during the spring (58.1%). There were no significant differences ( $p>0.05$ ) between the number of observation hours by either the time of the day, the day of the week, or the season (data not shown).

Although 5,881 one-hour observation periods were completed, only 2,999 (50.9%) had values greater than zero (Figure 4.1), resulting in a vacant percentage of 49.1%. The following features were mostly occupied: playground sets, swing sets, basketball courts, and splash pads. Open spaces were empty almost 90% of the time. These features (ball courts, ball fields, and games) were mostly empty.



**Figure 4.1. Percentage of occupied and empty observation periods (1-hour) for each feature type. (n=40 parks)**

### *Demographics of youth park users*

Tables 4.1-4.3 describe the use of features by type of neighborhood, stratified by gender, age group, and race/ethnicity.

**Table 4.1. Proportion of users observed in each activity feature type (n=8) within 40 neighborhood parks in New York and North Carolina according to gender.**

Type of feature	Gender (%)							
	New York				North Carolina			
	Majority Asian Neighborhood N=17,711		Majority Latino Neighborhood N=16,103		Majority Black Neighborhood N=6,091		Majority Latino Neighborhood N=1,505	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
Total %	35.7	64.3	39.2	60.8	32.6	67.4	34.8	65.2
Ball court	29.5 <sup>a</sup>	70.5 <sup>b</sup>	20.8 <sup>a</sup>	79.2 <sup>b</sup>	29.7 <sup>a</sup>	70.3 <sup>a</sup>	45.0 <sup>a</sup>	55.0 <sup>a</sup>
Ball field	40.9 <sup>a</sup>	59.1 <sup>b</sup>	15.5 <sup>a</sup>	84.5 <sup>b</sup>	18.5 <sup>a</sup>	81.5 <sup>b</sup>	39.6 <sup>a</sup>	60.4 <sup>b</sup>
Basketball court	9.2 <sup>a</sup>	90.8 <sup>b</sup>	9.3 <sup>a</sup>	90.7 <sup>b</sup>	11.3 <sup>a</sup>	88.7 <sup>b</sup>	9.5 <sup>b</sup>	90.5 <sup>b</sup>
Games	24.7 <sup>a</sup>	75.3 <sup>b</sup>	60.8 <sup>a</sup>	39.2 <sup>b</sup>	54.9 <sup>a</sup>	45.1 <sup>b</sup>	61.6 <sup>a</sup>	38.4 <sup>b</sup>
Open space	-	-	-	-	41.8 <sup>a</sup>	58.2 <sup>b</sup>	45.8 <sup>a</sup>	54.2 <sup>b</sup>
Playground set	47.4 <sup>a</sup>	52.6 <sup>b</sup>	50.6 <sup>a</sup>	49.4 <sup>b</sup>	50.1 <sup>a</sup>	49.9 <sup>b</sup>	52.5 <sup>a</sup>	47.5 <sup>b</sup>
Swing set	56.5 <sup>a</sup>	43.5 <sup>b</sup>	65.2 <sup>a</sup>	34.8 <sup>b</sup>	50.4 <sup>a</sup>	49.6 <sup>b</sup>	63.4 <sup>a</sup>	36.6 <sup>b</sup>
Splash pad	46.0 <sup>a</sup>	54.0 <sup>b</sup>	48.2 <sup>a</sup>	51.8 <sup>b</sup>	54.2 <sup>a</sup>	45.8 <sup>b</sup>	-	-
	p < 0.001		p < 0.001		p < 0.001		p < 0.001	

Notes: N = total youth observed.

Chi-Square Test, sig. <0.05. Superscript letters indicate pairwise comparisons for statistically significant differences in columns using z-test for proportion. Similar letters represent no significant differences.

**Table 4.2. Proportion of users observed in each activity feature type (n=8) within 40 neighborhood parks according to age group.**

Age group (%)												
New York							North Carolina					
Type of feature	Majority Asian Neighborhood N=17,711			Majority Latino Neighborhood N=16,103			Majority Black Neighborhood N=6,091			Majority Latino Neighborhood N=1,505		
	Children 0-4y	Children 5-10y	Teens 11-19y	Children 0-4y	Children 5-10y	Teens 11-19y	Children 0-4y	Children 5-10y	Teens 11-19y	Children 0-4y	Children 5-10y	Teens 11-19y
Total %	21.2	44.4	34.5	16.7	52.3	31.0	10.6	54.5	34.9	7.0	36.8	56.1
Ball court	5.5 <sup>a</sup>	21.4 <sup>b</sup>	73.1 <sup>c</sup>	5.1 <sup>a</sup>	39.7 <sup>b</sup>	55.2 <sup>c</sup>	8.5 <sup>a</sup>	53.8 <sup>a</sup>	37.7 <sup>a</sup>	0.0 <sup>a</sup>	100.0 <sup>a</sup>	0.0 <sup>a</sup>
Ball field	13.7 <sup>a</sup>	28.8 <sup>a</sup>	57.5 <sup>b</sup>	5.5 <sup>a</sup>	50.7 <sup>b</sup>	43.8 <sup>c</sup>	2.9 <sup>a</sup>	48.0 <sup>b</sup>	49.2 <sup>c</sup>	3.4 <sup>a</sup>	32.4 <sup>b</sup>	64.1 <sup>c</sup>
Basketball court	0.6 <sup>a</sup>	24.9 <sup>b</sup>	74.5 <sup>c</sup>	0.7 <sup>a</sup>	35.2 <sup>b</sup>	64.1 <sup>c</sup>	2.8 <sup>a</sup>	26.8 <sup>b</sup>	70.4 <sup>c</sup>	2.0 <sup>a</sup>	16.8 <sup>a</sup>	81.2 <sup>b</sup>
Games	15.1 <sup>a</sup>	68.1 <sup>b</sup>	16.9 <sup>a</sup>	25.5 <sup>a</sup>	39.2 <sup>a</sup>	35.3 <sup>a</sup>	25.0 <sup>a</sup>	62.7 <sup>b</sup>	12.3 <sup>c</sup>	8.1 <sup>a</sup>	81.4 <sup>a</sup>	10.5 <sup>b</sup>
Open space	-	-	-	-	-	-	21.4 <sup>a</sup>	48.0 <sup>b</sup>	30.6 <sup>b</sup>	20.8 <sup>a</sup>	54.2 <sup>a</sup>	25.0 <sup>b</sup>
Playground set	32.5 <sup>a</sup>	57.9 <sup>b</sup>	9.5 <sup>c</sup>	26.8 <sup>a</sup>	62.7 <sup>b</sup>	10.5 <sup>c</sup>	19.8 <sup>a</sup>	72.6 <sup>b</sup>	7.7 <sup>c</sup>	22.5 <sup>a</sup>	52.0 <sup>b</sup>	25.5 <sup>c</sup>
Swing set	36.6 <sup>a</sup>	51.0 <sup>b</sup>	12.4 <sup>c</sup>	22.3 <sup>a</sup>	56.4 <sup>b</sup>	21.3 <sup>c</sup>	15.4 <sup>a</sup>	66.7 <sup>a</sup>	17.9 <sup>b</sup>	11.2 <sup>a</sup>	58.0 <sup>a</sup>	30.7 <sup>b</sup>
Splash pad	31.9 <sup>a</sup>	55.1 <sup>b</sup>	13.1 <sup>c</sup>	25.2 <sup>a</sup>	58.5 <sup>b</sup>	16.3 <sup>c</sup>	33.3 <sup>a</sup>	45.8 <sup>b</sup>	20.8 <sup>b</sup>	-	-	-
	p < 0.001			p < 0.001			p < 0.001			p < 0.001		

Notes: N = total youth observed.

Chi-Square Test, sig. <0.05. Superscript letters indicate pairwise comparisons for statistically significant differences in columns using z-test for proportion. Similar letters represent no significant differences.

**Table 4.3. Proportion of users observed in each activity feature type (n=8) within 40 neighborhood parks according to race/ethnicity.**

Race/Ethnicity (%)														
New York									North Carolina					
Type of feature	Majority Asian Neighborhood N=17,711				Majority Latino Neighborhood N=16,103				Majority Black Neighborhood N=6,091			Majority Latino Neighborhood N=1,505		
	Asian	Black	Latino	Other	Asian	Black	Latino	Other	Black	Latino	Other	Black	Latino	Other
Total %	64.7	5.9	20.2	9.2	3.2	34.2	56.7	5.8	51.6	19.9	28.5	76.5	15.4	8.1
Ball court	60.7 <sup>a</sup>	1.4 <sup>a</sup>	33.1 <sup>a,b</sup>	4.8 <sup>a</sup>	0.6 <sup>a</sup>	50.4 <sup>a</sup>	48.4 <sup>a</sup>	0.6 <sup>a,b</sup>	26.6 <sup>a</sup>	40.2 <sup>a</sup>	33.2 <sup>a</sup>	100.0	0.0	0.0
Ball field	34.0 <sup>b</sup>	9.5 <sup>b</sup>	34.4 <sup>a,b</sup>	22.2 <sup>b</sup>	3.9 <sup>b</sup>	3.3 <sup>b</sup>	83.7 <sup>b</sup>	9.1 <sup>c,d</sup>	34.5 <sup>a</sup>	17.3 <sup>b</sup>	48.2 <sup>b</sup>	63.1	22.4	14.5
Basketball court	68.3 <sup>c</sup>	9.5 <sup>b</sup>	17.0 <sup>c</sup>	5.3 <sup>a</sup>	1.2 <sup>a</sup>	61.9 <sup>c</sup>	36.1 <sup>c</sup>	0.8 <sup>b</sup>	85.6 <sup>b</sup>	4.9 <sup>c</sup>	9.4 <sup>c</sup>	90.0	8.2	1.8
Games	43.4 <sup>b</sup>	0.6 <sup>a,c,d</sup>	44.0 <sup>b</sup>	12.0 <sup>b,c,d</sup>	19.6 <sup>c</sup>	47.1 <sup>a,c,d</sup>	33.3 <sup>a,c</sup>	0 <sup>a,b,c,d</sup>	61.3 <sup>c</sup>	26.5 <sup>d,e,f</sup>	12.3 <sup>c,d</sup>	76.7	14.0	9.3
Open space	-	-	-	-	-	-	-	-	79.6 <sup>b</sup>	11.2 <sup>b,c,f</sup>	9.2 <sup>c,d</sup>	70.8	25.0	4.2
Playground set	68.1 <sup>c</sup>	4.8 <sup>d</sup>	16.7 <sup>c</sup>	10.4 <sup>d</sup>	3.7 <sup>b</sup>	22.6 <sup>c</sup>	66.2 <sup>d</sup>	7.5 <sup>d</sup>	47.5 <sup>d</sup>	27.6 <sup>c</sup>	24.9 <sup>a,e</sup>	65.7	20.1	14.2
Swing set	59.2 <sup>a</sup>	2.4 <sup>a,c</sup>	30.4 <sup>a</sup>	8.0 <sup>d</sup>	4.8 <sup>b</sup>	32.2 <sup>d</sup>	53.4 <sup>a</sup>	9.6 <sup>c</sup>	61.0 <sup>c</sup>	20.9 <sup>b,d,f</sup>	18.1 <sup>d</sup>	75.1	17.6	7.3
Splash pad	59.6 <sup>a</sup>	4.4 <sup>c,d</sup>	20.7 <sup>d</sup>	15.3 <sup>c</sup>	2.3 <sup>a,b</sup>	24.7 <sup>c</sup>	70.6 <sup>d</sup>	2.3 <sup>a</sup>	100.0 <sup>b</sup>	0.0 <sup>b,c,d,e,f</sup>	0.0 <sup>c,d,e</sup>	-	-	-
	p < 0.001				p < 0.001				p < 0.001			p = 0.410		

Notes: N = total youth observed.

Chi-Square Test, sig. <0.05. Superscript letters indicate pairwise comparisons for statistically significant differences in columns using z-test for proportion. Similar letters represent no significant differences.

### Gender

Overall, the proportion of boys and girls who used a feature was dependent on the feature types ( $p < 0.001$ ) (Table 4.1). In both regions, more than 60% of the total sample of youth were boys. Swings sets had a higher proportion of girls, independent of neighborhood type. The highest proportion of boys was in basketball courts across the four neighborhood types (~90% across all neighborhoods). Playground sets and splash pads were used in similar proportions by boys and girls.

### Age

The proportion of feature use was dependent on age group ( $p < 0.001$ ) for all neighborhood types (Table 4.2). The total youth sample was 7-21% for children 0-4 years old, 37-54% for children 5-10 years old, and 31-45% for teens. Basketball courts were consistently more occupied by teens (between 64% and 81%), games (range: 39-81%), playground sets (range: 52-72%), swing sets (range: 51-66%); splash pads (range: 45-58%) had the highest proportions of children 5-10 years old. Ball courts were mostly used by teens in majority Asian (73%) and majority Latino (55%) neighborhoods in New York. In North Carolina, more children 5-10 years old used the same types of features in majority Black and majority Latino neighborhoods (54% and 100%, respectively). Ball fields were equally occupied by children 5-10 years old and teens in majority Latino neighborhood parks in New York and majority Black neighborhood parks in North Carolina.

### Race/Ethnicity

The proportion of feature use also depended on the perceived user race/ethnicity in parks located in New York neighborhoods and majority Black neighborhoods in North Carolina. Feature use in North Carolina majority Latino neighborhoods was independent of the perceived

race/ethnicity of observed youth ( $p=0.410$ ) (Table 4.3). Majority Asian neighborhoods had greater proportions of Asian youth on the ball courts (60.7%), the basketball courts (68.3%), and the playground sets (68.1%). In majority Latino neighborhoods in New York, greater proportions of perceived Latino youth were seen on the ball fields (83.7%), the playground sets (66.2%) and the splash pads (70.6%). Basketball courts were mostly used by Black youth in Latino neighborhoods in New York (62%), Black neighborhoods (86%), and Latino neighborhood parks in North Carolina (90%).

### ***Physical activity levels of youth park users***

Feature types were associated with specific proportions of youth physical activity in New York neighborhood parks ( $p=0.001$ ). North Carolina neighborhood parks had youth physical activity levels that were independent of the feature type ( $p>0.05$ ) (Table 4.4). Overall, basketball courts (58-61%), games (59%), and swing sets (58-62%) had the highest proportions of moderate physical activity. Ball fields (46-52%) and splash pads (43-47%) had the highest proportions of sedentary behavior. Vigorous physical activity was highest in basketball courts (18-19%), games (17-20%), and playground sets (18-19%). All feature types had at least 50% of youth in moderate-to-vigorous physical activity in New York neighborhood parks. Though North Carolina neighborhood park physical activity levels were not statistically related to feature types, there was a trend similar to the New York neighborhoods. However, open spaces were only available in North Carolina parks and had high (50% or more) proportions of users being sedentary.

### ***Temporal patterns of use of features by youth park users***

Use of park features by time of the day, day of the week, and season appears in Tables 4.5-4.7.

**Table 4.4. Description of use of activity features (total number of users observed) according to physical activity levels by neighborhood where parks were located in NY and NC (n=8)**

Type of feature	Physical Activity Level (%)											
	New York						North Carolina					
	Majority Asian Neighborhood N=17,711			Majority Latino Neighborhood N=16,103			Majority Black Neighborhood N=6,091			Majority Latino Neighborhood N=1,505		
Total %	Sed	Mod	Vig	Sed	Mod	Vig	Sed	Mod	Vig	Sed	Mod	Vig
Total %	31.1	51.8	17.0	31.3	51.3	17.4	29.1	51.8	19.0	27.8	55.6	16.6
Ball court	33.0 <sup>a</sup>	52.7 <sup>a</sup>	14.3 <sup>a,b,c</sup>	26.0 <sup>a</sup>	54.1 <sup>a,b</sup>	19.9 <sup>a</sup>	39.9	46.5	13.6	55.0	35.0	10.0
Ball field	52.0 <sup>b</sup>	37.5 <sup>b</sup>	10.6 <sup>c</sup>	45.9 <sup>b</sup>	40.5 <sup>c</sup>	13.6 <sup>b,c</sup>	29.2	50.5	20.3	28.7	61.7	9.6
Basketball court	21.6 <sup>c</sup>	60.8 <sup>c</sup>	17.6 <sup>b,d</sup>	23.7 <sup>a</sup>	57.6 <sup>b</sup>	18.7 <sup>a</sup>	20.1	57.6	22.3	22.5	55.8	21.6
Games	24.1 <sup>a,c</sup>	59.0 <sup>a,c</sup>	16.9 <sup>a,b,c,d</sup>	21.6 <sup>a,c,d</sup>	58.8 <sup>a,b,c,d</sup>	19.6 <sup>a,b,c</sup>	36.8	53.4	9.8	11.6	77.9	10.5
Open space	-	-	-	-	-	-	71.4	19.4	9.2	50.0	41.7	8.3
Playground set	34.2 <sup>a</sup>	46.8 <sup>d</sup>	19.1 <sup>d</sup>	35.7 <sup>d</sup>	46.2 <sup>d</sup>	18.2 <sup>a</sup>	31.8	53.6	14.6	46.6	39.2	14.2
Swing set	23.5 <sup>c</sup>	62.5 <sup>c</sup>	14.1 <sup>a,c</sup>	26.4 <sup>a</sup>	57.7 <sup>b</sup>	15.9 <sup>a,c</sup>	23.8	49.8	26.4	22.9	53.7	23.4
Splash pad	47.4 <sup>b</sup>	41.5 <sup>b</sup>	11.0 <sup>a,c</sup>	42.9 <sup>b,c</sup>	46.9 <sup>a,c,d</sup>	10.1 <sup>b</sup>	20.8	45.8	33.3	-	-	-
	p < 0.001			p = 0.001			p = 0.882			p = 0.898		

Notes: N = total youth observed. Sed = sedentary; Mod = moderate/walking; Vig = vigorous.

Chi-Square Test, sig. <0.05. Superscript letters indicate pairwise comparisons for statistically significant differences in columns using z-test for proportion. Similar letters represent no significant differences.

### Time of day

The average number of children observed per hour ranged between zero (e.g., in the morning or in the open spaces located in North Carolina neighborhood parks) and 27 children (e.g., the ball fields in New York Latino neighborhoods; Table 4.5). Ball courts saw a relatively more average number of users in the evening compared to the morning in majority Asian, Black, and Latino neighborhoods in New York, ranging from 200% to 900% more per hour in the evening compared to the morning. The average number of users observed per hour in basketball courts was significantly different in the evening from the same number in the morning across all neighborhood types, with a more than 200% relative increase. Playground sets and swing sets were also more populated, on average, in the evenings than in the mornings (50%+ increase).

**Table 4.5. Mean number of youth observed per hour in each type of activity feature stratified by time of the day (morning, afternoon, and evening).**

Feature type	Time of the Day Mean (SD)											
	New York						North Carolina					
	Majority Asian Neighborhood N = 1,300			Majority Latino Neighborhood N = 1,418			Majority Black Neighborhood N = 2,432			Majority Latino Neighborhood N = 731		
	Morning	Afternoon	Evening	Morning	Afternoon	Evening	Morning	Afternoon	Evening	Morning	Afternoon	Evening
<b>Total %</b>	<b>23.0</b>	<b>34.6</b>	<b>42.4</b>	<b>22.8</b>	<b>33.2</b>	<b>43.9</b>	<b>20.3</b>	<b>41.4</b>	<b>38.3</b>	<b>20.9</b>	<b>39.1</b>	<b>39.9</b>
Ball court	1.8 (4.9) <sup>a</sup>	5.7 (6.8) <sup>b</sup>	5.8 (7.4) <sup>b</sup>	1.0 (2.1) <sup>a</sup>	3.7 (5.8) <sup>b</sup>	6.1 (9.9) <sup>b</sup>	0.0 (0.6) <sup>a</sup>	0.7 (2.5) <sup>b</sup>	0.7 (2.3) <sup>b</sup>	0.0 (0.0)	0.2 (1.0)	1.1 (2.8)
Ball field	19.6 (31.6)	17.6 (16.9)	12.1 (17.6)	17.1 (21.2)	26.8 (22.1)	23.7 (17.3)	2.1 (7.8) <sup>a</sup>	3.8 (11.6) <sup>a</sup>	7.4 (17.2) <sup>b</sup>	0.1 (0.5)	4.2 (11.5)	3.2 (8.1)
Basketball court	7.3 (9.7) <sup>a</sup>	16.5 (15.3) <sup>b</sup>	24.6 (20.4) <sup>c</sup>	5.6 (14.5) <sup>a</sup>	17.0 (13.6) <sup>b</sup>	18.1 (15.6) <sup>b</sup>	0.2 (1.0) <sup>a</sup>	2.7 (5.6) <sup>b</sup>	4.3 (6.8) <sup>c</sup>	0.6 (2.6) <sup>a</sup>	2.8 (6.5) <sup>a,b</sup>	6.2 (11.2) <sup>b</sup>
Games	0.7 (1.9) <sup>a</sup>	1.6 (3.0) <sup>a,b</sup>	4.3 (4.9) <sup>b</sup>	0.1 (0.0)	0.7 (1.3)	1.3 (4.0)	0.3 (1.3) <sup>a</sup>	1.8 (3.5) <sup>b</sup>	1.8 (3.4) <sup>b</sup>	0.5 (1.4)	1.0 (2.7)	1.6 (4.7)
Open space	-	-	-	-	-	-	0.2 (1.0)	0.9 (4.0)	0.6 (3.7)	0.0 (0.0)	0.3 (1.1)	0.4 (1.1)
Playground set	13.0 (13.8) <sup>a</sup>	16.1(13.8) <sup>a,b</sup>	21.7 (18.0) <sup>c</sup>	4.9 (6.4) <sup>a</sup>	11.8 (12.0) <sup>b</sup>	18.0 (15.9) <sup>c</sup>	1.7 (4.4) <sup>a</sup>	4.1 (7.4) <sup>b</sup>	2.9 (4.7) <sup>b</sup>	0.7 (1.3)	1.6 (3.2)	1.9 (3.8)
Swing set	6.1 (4.9) <sup>a</sup>	9.3 (6.5) <sup>a</sup>	20.4 (11.7) <sup>b</sup>	5.0 (7.1) <sup>a</sup>	12.6 (9.6) <sup>b</sup>	16.8 (13.2) <sup>b</sup>	1.1 (2.6) <sup>a</sup>	2.7 (4.4) <sup>b</sup>	3.6 (5.7) <sup>b</sup>	1.0 (2.8)	1.5 (2.9)	2.4 (4.7)
Splash pad	4.1 (5.4)	9.0 (12.8)	9.3 (10.6)	1.2 (1.9) <sup>a</sup>	3.2 (6.4) <sup>a</sup>	7.1 (8.2) <sup>b</sup>	0.0 (0.0)	1.4 (4.4)	0.0 (0.0)	-	-	-

Notes: N = total 1-hour periods of observation.

Superscript letters indicate statistically significant pairwise comparisons between means ( $p < 0.001$ ), analyzed with non-parametric Kruskal-Wallis test. Bonferroni correction was used for multiple categories.

$\Delta\%$  = delta percentage refers to the relative difference between the mean number of users observed in the evening when compared to the mean number of users observed in the morning.

**Table 4.6. Mean number of youth observed per hour in each type of activity feature stratified by day of the week (weekday and weekend).**

Type of feature	Day of the Week Mean (SD)							
	New York				North Carolina			
	Majority Asian Neighborhood N = 1,300		Majority Latino Neighborhood N = 1,418		Majority Black Neighborhood N = 2,432		Majority Latino Neighborhood N = 731	
Total %	Week	Weekend	Week	Weekend	Week	Weekend	Week	Weekend
Ball court	53.5	46.5	54.9	45.1	52.2	47.8	56.9	43.1
	4.7 (7.1)	5.0 (6.6)	5.0 (8.5) <sup>a</sup>	2.9 (6.4) <sup>b</sup>	0.4 (1.5) <sup>a</sup>	0.8 (2.7) <sup>b</sup>	0.7 (2.5)	0.3 (0.9)
			$\Delta\% = -40$		$\Delta\% = 150$			
Ball field	15.3 (22.3)	16.2 (19.6)	20.4 (19.1)	26.4 (20.3)	6.1 (16.0)	3.5 (10.3)	1.9 (6.6)	4.4 (11.2)
Basketball court	18.4 (19.1)	17.1 (16.5)	15.2 (15.2)	14.2 (16.1)	2.7 (5.8)	2.9 (5.7)	2.9 (7.0)	4.8 (10.2)
Games	2.8 (4.6)	2.2 (3.2)	1.2 (3.5)	0.3 (1.0)	1.4 (2.8)	1.6 (3.6)	0.7 (1.7)	1.7 (4.8)
Open space	-	-	-	-	0.2 (1.0)	1.2 (5.0)	0.2 (1.0)	0.4 (1.0)
Playground set	17.3 (15.4)	18.3 (16.9)	12.2 (12.2)	13.8 (15.7)	3.2 (5.4)	3.1 (6.5)	0.8 (2.2)	2.7 (4.1)
							$\Delta\% = 200$	
Swing set	12.4 (10.7)	14.3 (10.9)	13.3 (11.2)	12.0 (12.5)	2.6 (4.3)	2.8 (5.2)	1.2 (2.7)	2.4 (4.6)
Splash pad	7.6 (9.4)	8.5 (12.0)	4.4 (7.0)	4.6 (7.2)	0.0 (0.0)	1.2 (4.0)	-	-

Notes: N = total 1-hour periods of observation.

Superscript letters indicate statistically significant pairwise comparisons between means ( $p < 0.001$ ), analyzed with non-parametric Kruskal-Wallis test. Bonferroni correction was used for multiple categories.

$\Delta\%$  = delta percentage refers to the relative difference between the mean number of users observed during the weekend when compared to the mean number of users observed on weekdays.

**Table 4.7. Average number of youth observed per hour in each type of activity feature stratified by season (spring and summer).**

Type of feature	Season Mean (SD)									
	New York				North Carolina					
	Majority Asian Neighborhood N = 1,300		Majority Latino Neighborhood N = 1,418		Majority Black Neighborhood N = 2,432		Majority Latino Neighborhood N = 731			
Total %	Spring	Summer	Spring	Summer	Spring	Summer	Spring	Summer		
Ball court	55.5	5.5 (7.0) <sup>a</sup>	3.9 (6.5) <sup>b</sup>	54.1	4.7 (7.7)	3.4 (7.7)	61.5	38.5	59.2	40.8
		$\Delta\% = -33$								
Ball field	16.6 (16.8)	14.5 (25.7)	27.2 (20.3)	18.6 (18.4)	5.2 (13.1)	4.3 (14.4)	3.8 (10.5)	1.7 (5.7)		
Basketball court	19.5 (17.8) <sup>a</sup>	15.7 (18.0) <sup>b</sup>	17.5 (13.0) <sup>a</sup>	11.7 (17.6) <sup>b</sup>	3.4 (6.5) <sup>a</sup>	1.9 (4.2) <sup>b</sup>	4.0 (8.3)	3.2 (8.7)		
		$\Delta\% = -16$			$\Delta\% = -29$					
Games	2.5 (4.4)	2.6 (3.6)	1.3 (3.8)	0.3 (1.0)	1.9 (3.5) <sup>a</sup>	1.0 (2.6) <sup>b</sup>	1.5 (4.4)	0.6 (1.5)		
					$\Delta\% = -50$					
Open space	-	-	-	-	0.9 (4.4)	0.2 (1.0)	0.3 (1.0)	0.3 (1.0)		
Playground set	17.7 (15.7)	17.9 (16.6)	13.2 (13.6)	12.7 (14.5)	3.9 (6.7) <sup>a</sup>	1.9 (4.3) <sup>b</sup>	1.7 (2.9)	1.4 (3.7)		
					$\Delta\% = -50$					
Swing set	11.1 (7.9)	15.8 (13.1)	13.0 (10.5)	12.3 (13.2)	3.1 (4.7) <sup>a</sup>	2.1 (4.9) <sup>b</sup>	1.6 (3.1)	2.0 (4.5)		
					$\Delta\% = -33$					
Splash pad	9.7 (12.6)	5.8 (7.3)	4.5 (7.6)	4.5 (6.4)	0.9 (3.5)	0.0 (0.0)	-	-		

Notes: N = total 1-hour periods of observation.

Superscript letters indicate statistically significant pairwise comparisons between means ( $p < 0.001$ ), analyzed with non-parametric Kruskal-Wallis test. Bonferroni correction was used for multiple categories.

$\Delta\%$  = delta percentage refers to the relative difference between the mean number of users observed during the summer when compared to the mean number of users observed in the spring.

### Day of the week

There were few statistically significant differences in feature use by week day and weekend days ( $p < 0.001$ ) (Table 4.6). In New York majority Latino neighborhood parks, there was a relative decrease of 40% in the average number of youth observed in ball courts on weekends compared to week days. On ball courts in majority Black neighborhood parks there was an increase of 150% in the average number of youth during weekends compared to weekdays. Playgrounds in Latino neighborhood parks in North Carolina saw an increase of 200% in the average number of youth users on weekends compared to weekdays.

### Season

The average number of youth observed in park features during spring and summer appears in Table 4.7. There was a decrease of at least 16% in the number of observed users by season in majority Asian and Latino neighborhood parks in New York and majority Black neighborhood parks in North Carolina. Ball courts had a 33% decrease in use during the summer when compared to the spring in majority Asian neighborhood parks. Basketball courts had a decline in use from spring to summer (ranging from 16% to 33%) in all neighborhoods except for majority Latino neighborhoods in North Carolina, where the average was numerically lower in the summer but there was no statistical significance to the difference. Games and playground sets showed a 50% decrease in the summer compared to spring in majority Black neighborhood parks and swing sets were 33% higher in terms of the average number of users in the spring compared to summer.

## Discussion

Almost 50% of target areas were empty at the time of observation. This is not dissimilar to most studies using SOPARC to observe park spaces, where empty areas range from 53% to 76% of total observations, with some studies reporting more than 80% (Evenson et al., 2016). These

empty cases, however, are a part of the use patterns of the spaces being observed. However, we were interested in knowing the characteristics of users, which suggested the elimination of the empty cases in our analysis; on the other hand, for feature use patterns during the period of the day, the day of the week, or the season all observations were accounted for, including empty scans.

We found boys and girls to be distinctly differently distributed across park features. Boys were more frequent than girls in almost all feature types across the 40 parks in low-income communities of color. This is consistent with other studies reporting the use of SOPARC protocols to observe youth in parks, i.e., finding over 50% of users to be male (Baran et al., 2013; Joseph & Maddock, 2016). We also found that playground sets were the feature type most frequently used by girls. Basketball and ball fields were predominantly used by males. Floyd et al. (2011) also reported that North Carolina girls were more likely to be found on playgrounds and less likely on courts. Girls were also the majority on swing sets (over 55%) in New York neighborhood parks. This may be associated with the fact that all swing sets in New York City parks were fenced in, which may have provided a greater sense of safety. Safety is a commonly cited concern by the parents of young children, especially girls (Loukaitou-Sideris & Sideris, 2010; Ogletree et al., 2020; Wall et al., 2012).

We determined that playgrounds were mostly populated by children 5-10 years old across all neighborhood park types. Ball courts, ball fields, and basketball courts were populated mostly more by teens. This is consistent with the report of Floyd et al. (2011), who, after examining 20 neighborhood parks in Durham, North Carolina, found that youth 13-18 years old were observed in greater proportion in courts (33%) and 6-12-year-olds were mostly seen in playgrounds (35%). Basketball courts were associated with use by boys, especially adolescents (Baran et al., 2013). The greater prevalence of 5-10 year-old children in total may be an overestimation on our part, as

this was the focus age group of the PARC<sup>3</sup> project, which provided the data for this study (Marquet et al., 2019). When observers were trained, they were instructed to default borderline age groups to the middle youth category. For example, if an observer could not perceive whether a child was four or five years old, they should default to the 5-10 years old category.

Regarding physical activity levels, we found moderate physical activity was the most prevalent level of activity in all neighborhood parks. An important aspect of the use of the SOPARC protocol is that the physical activity categories are divided into sedentary, moderate or walking, and vigorous (McKenzie et al., 2006); although the cut between sedentary and moderate may be adapted according to a study's protocol, frequently standing in place is considered as a sedentary activity. We defined sitting, laying or standing as sedentary, but if a participant was standing but pushing, pulling, or any other movement that could be observed as stationary but that led to increased heart rate, they were considered to be moderately active, e.g., a teen pushing a younger sibling on swings. This means the moderate or walking category was the default for any level of activity beyond sedentary and prior to vigorous, which may have inflated the observations of moderate activity.

We found that the most popular features used in parks in low-income communities of color comprised basketball courts for boys, and swing sets for girls. Playground sets and splash pads were used in similar proportions by both boys and girls. Basketball courts were mostly used by teens; games, playground sets, swing sets, and splash pads, by children 5-10 years old. Ball courts were filled with teens in New York but had a greater presence of children 5-10 years old in North Carolina neighborhood park features. Young children (0-4 years old) were 20% or less of all youth feature users.

Ball fields and splash pads had the highest proportions of sedentary users. Ball fields were mostly used for baseball, which explains why the momentary scans might have observed users in a still, standing position. For splash pads, their structures either had water shooting from the ground, coming out of arches, or was conducive of sedentary behavior. Children often chose to stand or sit in those places to enjoy the water, thus registering more sedentary behavior. Similarly, when splash pads did not have the water turned on, children used the area as if it were simply an open space. In North Carolina, open spaces had the highest proportion of observations of sedentary users; Andersen et. Al (2015) reported that solid surface areas similarly had a greater proportion of sedentary activities than playgrounds. In contrast, a sample of school age children were found to be more active in outdoor green environments where there is more space for free play and unstructured sports (Coombes et al., 2013). Open greenspaces without man-built elements have been shown more favorable to children's physical activity (Lachowycz & Jones, 2013). These contradicting findings are food for thought on what features contribute to decisions by children to be active or sedentary in open spaces. Previous researchers showed that youth's use of open spaces is often dictated by who else is there and how active they are, i.e., a combination of the structures available, the presence of friends, and personal motivation (Veitch et al., 2007). In North Carolina, frequently parks were not very populated, limiting creativity or diversity in use, benefiting the use of these spaces for sitting or being sedentary.

In all neighborhood parks the use of most features was higher during spring. In New York, playground sets and swing sets were the only features with fewer youth during spring when compared to summer. Parks in majority Black neighborhoods had 50% more youth on playgrounds during summer when compared to spring. Interestingly, 150 non-White populations assessed using accelerometers in the school-year and the summer were found to be overall more active during the

school-year time than summer (James F. Sallis et al., 2019). This could be due to transportation, which has been identified as a great contributor for physical activity in teens (Alberico et al., 2017). Summer has also been shown as a time when physical activity decreases and screen time increases. A majority of Black adolescents were shown to have a significant increase in screen time during summer (Sallis et al., 2019). It may be that playgrounds are more occupied by younger children during the summer while adolescents choose more sedentary activities. These results suggest that interventions to increase physical activity levels may need a seasonal specificity.

### ***Weaknesses and Strengths***

Our results do not come without limitations. In addition to those mentioned above, features were not equally distributed across the 40 parks, but we aggregated our analysis by neighborhood type, which eliminated some of those differences. The quality of park features was not taken into consideration. Perceived gender, age, and race/ethnicity are dependent on the adequate training of observers thus is more prone to error than self-report (Campbell et al., 2020; Harris, 2002). Though only three cities were included, the large sample size is a strength. The number of days and hours of observations distributed in the 40 parks followed a common and acceptable protocol (Evenson et al., 2016; McKenzie et al., 2006) We used a valid and reliable tool (SOPARC) and had good inter-observer agreement, despite the large number of observers (20 research assistants) and the modifications that allowed data to be collected at the individual level (Marquet et al., 2019).

### **Conclusions**

We identified youth's use of park features in diverse, low-income community parks. We described use of specific features by gender, age, race/ethnicity, and physical activity level, as well

as time of the day, day of the week, and season. A total of 5,881 1-hour observation periods were completed for the 341 features distributed across 40 parks in New York City, Raleigh, and Durham. Over 40,000 youth 19 years old and younger were observed. However, almost 50% of those observation periods saw no youth in the park features. There is a special need to identify whether youth are using other areas of the parks not included in the traditionally mapped areas for physical activity.

We provide practical evidence to inform park design and management to create strategies when building or renovating parks in low-income, diverse neighborhoods. It is important to consider culture-specific uses of spaces, especially when those are used by diverse populations, to encourage building resilience in youth of color. Our results can contribute to landscape planning strategies to design parks with the potential to increase park-based physical activity to help improve the odds of meeting the guidelines for health.

## **CHAPTER 5: USE OF GPS AND ACCELEROMETRY TO DESCRIBE PARK USE AND PARK-BASED PHYSICAL ACTIVITY IN LOW-INCOME COMMUNITIES OF COLOR**

### **Introduction**

Physical activity is known for its health benefits, especially when attempting to prevent chronic disease, sedentary behavior, and obesity (Kohl et al., 2012; Lee et al., 2012; Roychowdhury, 2020). Although this is true for all, children can especially benefit from healthy behaviors that can extend throughout their lives. Currently, there are health inequities in the amount of physical activity children are able to get per week: more than 73% of youth in the U.S. does not meet the recommendations for physical activity, with Asian (84.7%), Latino (79.1%), and Black (78.9%) youth having the largest proportions of physical inactivity (Centers for Disease Control and Prevention, 2019). Parks are potential promoters of physical activity and contribute to physical and mental health, social cohesion, and other well-being outcomes (Bedimo-Rung et al., 2005; Kaczynski et al., 2008). We sought to better understand the spatiotemporal patterns of park-based physical activity by a diverse group of children to better inform park designers of active spaces for all youth.

Parks can encourage physical activity when more features are available, such as fields and courts (Kaczynski et al., 2008; Stewart et al., 2018). Playgrounds and courts have also been associated with greater intensity physical activity, with activity in open spaces found to be mostly sedentary (Cohen et al., 2007; Floyd et al., 2008; Lindberg & Schipperijn, 2015). Use of park features has been shown to be distinctive when considering gender, age, and race/ethnicity. Girls are more present in playgrounds, swings, and splash pads; children of younger age were more prevalent in those same features. Perceived Asian and Black youth were predominant in basketball courts, more perceived Latinos used ball fields (Alberico et al., 2021).

Though there are several studies informing the diverse features of playgrounds and their potential association with levels of physical activity, the majority of these studies have used observations or self-reported measures (Azlina & Zulkiflee, 2012; Czalczyńska-Podolska, 2014). Direct observation methods have been largely used to understand use of parks and characteristics of users. Tools such as SOPARC (Evenson et al., 2016; McKenzie et al., 2006) allows observers to sample park users in distinct features or park zones and note their physical activity levels, as well as perceived demographics such as age, gender, and race/ethnicity. However, it could be difficult to accurately determine use of parks if many users are present, plus the use of SOPARC limits the locations to the target areas and the time to periods when the observations occur. Moreover, systematic observations generally identify use of space instead of user behavior, which can lead to a spatial or temporal uncertainty about the actual behaviors being investigated, i.e., a specific playground zone may be scanned for use four times during an hour, but this only provides information on use of that space during that hour. This approach's design inadvertently omits how children and youth are moving across spaces, changing their activity patterns, and their overall energy expenditure during a park visit.

Although target areas for observation are typically set by the study protocol, user behavior can create their own space for use during a park visit. Accelerometers and GPS are adequate for the advancement of this topic (Dunton et al., 2014; Evenson et al., 2013). However, the use of devices and new technology can be expensive and requires expertise. Studies to date using devices to capture children's behavior have been primarily conducted in schoolyards or throughout a week of free-living assessment which may have included activity in a park (Andersen et al., 2015; Dunton et al., 2014; J. S. Ward et al., 2016). Also, park-based physical activity has rarely been examined at the individual level, especially in children visiting parks in low-income communities

of color. Such an investigation may better inform park design to offer more conducive environments for physical activity and play across a diversity of children.

In addition to understanding children's physical activity, these device-based measurements can better inform design, management, and renovation. There is a lack of evidence to inform what is essential or preferable when building or redeveloping a park: what structures should be built, maintained or renovated. When building parks, designers could benefit from knowing which features are preferred by different users to better inform choice of features and how to arrange them (Hjort et al., 2018). It is important to develop more precise research protocols to allow a better understanding of park feature use, which has direct implication for park planners and designers in creating spaces for active behavior in a community (Kaczynski et al., 2008).

Understanding the use of parks and their features by children of different backgrounds can help tailor parks to the populations in the communities where parks are being renovated or designed. Moreover, when building spaces to promote physical activity, it is important to take into account which types of features aid in making the areas within parks more active (Lindberg & Schipperijn, 2015). Thus, to support evidence-based decision-making in park design, our aim was to describe 5-10-year-olds' park-based physical activity according to demographic, temporal, and spatial characteristics within parks located in low-income, diverse neighborhoods. We used GPS and accelerometer data generated by children while inside neighborhood parks in two U.S. regions to identify the locations where children play and are physically active. We investigated the relationships between park-based physical activity, stratifying by demographics and temporal characteristics.

## **Methods**

### ***Park selection***

A large study was conducted during 2017-2018 in New York City (NY) as well as Raleigh and Durham (NC), where low-income community parks were selected for direct observations, park quality audits, and street segment and walkability audits (Marquet, Hipp, et al., 2019). Low-income areas were defined as block groups with median household income below 80% of the median county income (U.S. Department of Housing and Urban Development, 2017). The estimated number of children by race/ethnicity was calculated using a quarter mile buffer around parks for NY and a half-mile buffer for NC due to population density. Demographics data was based on 2015 American Community Survey (ACS) 5-year block group estimates (U.S. Census Bureau, 2014). Parks in neighborhoods with majority Asian or majority Latino youth in NY and majority Black or majority Latino youth in NC were identified. Forty parks were selected for inclusion in the broader study, 10 in majority Asian neighborhoods and 10 in majority Latino neighborhoods in New York, and 15 in majority Black neighborhoods and 5 in majority Latino neighborhoods in North Carolina.

Using a handheld GPS (Trimble GeoXT), all park boundaries and individual spaces for physical activity (for our purposes defined as features, e.g., swing sets and playground sets) were geolocated in GIS and areas were calculated in ArcGIS. Of the original 40 parks, we selected 12 parks, six per region, based on scouting visits which determined higher density of accurate GPS points and likelihood of observing children 5-10 years old. The final count was three parks in majority Asian neighborhoods, five parks in majority Latino neighborhoods, and four parks in majority Black neighborhoods. The mean size of the parks was 48,887 square meters, with parks in NY being smaller in area than NC (10,042 m<sup>2</sup> vs 87,731 m<sup>2</sup>, respectively).

Features included multi-purpose ball fields, courts (e.g., tennis, volleyball, soccer, handball, and basketball), games painted on the ground (e.g., hopscotch), playground sets including slides and monkey bars, splash pads, and swing sets. These were selected for direct observation as part of the PARC<sup>3</sup> project (J. H. Huang et al., 2020; Oriol Marquet, Aaron Hipp, et al., 2019) and the same features were used in portions of our analysis. Participant children were not limited to where in the park they could play during their park visit. All features were further classified into seven categories: ball fields (multi-purpose, baseball, and soccer), ball courts (tennis, volleyball, soccer, and handball), basketball courts, games (hopscotch, ace ball), playground sets (multi-stations, slides, and monkey bars), splash pads, and swing sets. All park areas outside of the identified and mapped features, but within park boundaries, were considered as “Other” for analysis. A total of 124 features were initially mapped with an additional 12 identified as Other; one per park (Table 5.1). There was an average of 11 features in each of the 12 parks. There were no open spaces in NY and no splash pads in NC.

**Table 5.1. Description of activity features per type (n=136).**

Type of feature	NY (n=6 parks)		NC (n=6 parks)		Total (n=12 parks)	
	Features N (%)	Size (m <sup>2</sup> ) Mean (SD)	Features N (%)	Size (m <sup>2</sup> ) Mean (SD)	Features N (%)	Size (m <sup>2</sup> ) Mean (SD)
Ball court	14 (20.0)	280 (168)	12 (18.2)	694 (450)	26	471 (385)
Ball field	2 (2.9)	2,209 (244)	12 (18.2)	6,017 (2,580)	14	5473 (2,748)
Basketball court	15 (21.4)	305 (133)	9 (13.6)	430 (207)	24	352 (171)
Games	3 (4.3)	61 (8)	1 (1.5)	54 (-)	4	59 (7)
Open space	-	-	5 (7.6)	670 (1,010)	5	670 (1,010)
Playground set	16 (22.9)	186 (79)	13 (19.7)	195 (94)	29	190 (84)
Splash pad	5 (7.1)	141 (123)	-	-	5	141 (123)
Swing set	8 (11.4)	144 (34)	8 (12.1)	167 (106)	16	156 (77)
Other	6 (10.0)	2,828 (4,350)	6 (9.1)	72,451 (48,993)	12	34,962 (48,111)
Total	70		66		136	

Notes: SD = standard deviation.

### *Sample and data collection*

Children 5-10 years old who were visiting the park accompanied by a parent or caregiver were participants in this study. Parental/caregiver consent was required as well as child assent. The final sample included 409 children. The study was approved by IRB at North Carolina State University.

The researchers walked through the features in the park and approached any potential parent asking if they were accompanying a child 5-10 years old. After describing the study and asking if they would like to participate, the parent signed a consent and the child provided verbal assent. The child was then fitted with a belt containing two devices: an Actigraph GT3+ accelerometer (capture rate of 30Hz) and a QStarz GPS receiver (capture rate at 1s). These devices measured movement and where children were during free play, respectively. The belt was worn on the hip, with the accelerometer on the right side and GPS device on the left. Participants were asked to wear the belt in the park for at least 15 minutes. In the meantime, parents were asked to respond to a short survey (tablet-based or paper) which included the demographics of themselves and the children, such as gender, age, and race/ethnicity. Parents/guardians received a US\$10 gift card as an incentive for participation.

Each park was visited on one weekday and one weekend day. Visits were in spring/school year and summer 2017-2018, such that each of the parks was visited a total of two times, once per season. The goal was to monitor 15-20 children per park, per day. As NC parks were less populated, multiple visits were necessary to achieve the final numbers presented here; that is, we could not consent 20 children during one single visit per park, so the park was visited multiple days. Each park visit was conducted by two trained researchers. In Asian neighborhoods, a Mandarin speaker was hired to translate for any potential participants. At least one team member

who spoke Spanish was present in all parks during data collection. Recruitment cards, consent, and surveys were offered in English, Spanish, and Simplified Chinese.

### ***Data processing***

For classification of activity, accelerometer and GPS files were joined by timestamp using an online application (HABITUS, Denmark). Settings included accelerometer cut-points for youth at 15-second epochs categorizing physical activity into sedentary (0-25), light (26-573), moderate (574-1002), and vigorous ( $\geq 1003$ ) (Evenson et al., 2008). Missing GPS data were resolved using the last known location. Final valid data were defined by a minimum of 15 minutes or 60 15-second location points; 357 participants were included in the final sample.

A 10-meter buffer was added to the twelve park boundary polygons and 1-meter buffers to each feature type (except Other) to account for signal error of GPS receivers as previously reported in the literature (Schipperijn et al., 2014). The GPS point data from participant-worn units were then clipped to the area inside the park boundaries and, later, to the feature polygon. All points outside of features but within park boundaries were considered as being in the “Other” feature category. A spatial join in ArcGIS was used to append feature characteristics, including area and type of feature, with individual participant points at every 15 seconds. The total number of points inside park boundaries (n=38,978) was used to reference the total time monitored and percentage of time for each type of feature.

Participant information, via parent/caregiver survey, was linked to the individual participant points to provide demographics such as gender, age, and race/ethnicity. Parent-reported gender (girl, boy), age (5-6, 7-8, 9-10 years old), and race/ethnicity (Asian, Black, Latino, White, Other) were used as categories, physical activity (sedentary, light, moderate to vigorous), patterns

of use by season (spring, summer) and day of the week (weekday, weekend), and use of space by feature types.

### *Analysis and outcomes*

Descriptive statistics were used to describe the sample (Table 5.2). Categorical variables (day of the week, season, gender, age, and race/ethnicity) were compared between regions using Chi-squared tests of independence, to answer the question: “Is there a significant relationship between park region and use by day of the week, season, gender, age, and race/ethnicity?” Our null hypothesis was that the variables were independent and there were no statistical differences in feature use between the two regions. If the p-values for the Pearson Chi-Square coefficient were less than 0.05 (for an alpha level associated with a 95% confidence level), then the null hypothesis was rejected and the variables considered to be dependent or statistically related. Central tendency was used to describe continuous variables such as physical activity outcomes. We used non-parametric Kruskal-Wallis tests for minutes spent in sedentary behavior, light activity, and MVPA due to lack of normality in the dataset. The test identified the differences in mean proportion in each of the activity levels by demographic and temporal variables. Significance values were adjusted by the Bonferroni correction for multiple tests and the confidence interval was kept at 95%. All analyses were performed in IBM SPSS 25.0 (2018).

### **Results**

A total of 357 participants generated 10,165 minutes of activity as ascertained via accelerometer and GPS. Of those participants included in the final sample, 200 were in New York City (NY) and 157 were in Raleigh and Durham (NC). Participant demographic and temporal

characteristics are presented in Table 5.2. The day of the week of data collection was dependent on the region. NC participants were mostly assessed on weekends (74.5%). The proportion of boys and girls and race/ethnicity also differed by region: NY participants were mostly girls (53.0%); NC participants were mostly boys (59.9%). Device wear time was, on average, 28 minutes in total, with participants in NY wearing devices longer (29 minutes) than NC participants (27 minutes). On the other hand, participants in NC had higher activity count per minute (2,352), and distance per minute (25m) when compared to NY participants (2,011 and 19m, respectively). Overall, children spent 60% of their time in the park in light activity and over 30% in MVPA. Average minutes ( $18.2 \pm 8.6$ ) and proportion of light activity (61.9%) were significantly higher in NY. MVPA was achieved by a significantly higher proportion of children in NC (36.3%) when compared to NY (29.6%).

**Table 5.2. Description of sample according to temporal, demographics, and physical activity characteristics of children monitored while using parks in NY and NC.**

	Participants N (%)			p-value
	NY (n=200)	NC (n=157)	Total (n=357)	
<sup>a</sup> Day of the week				
Weekday	98 (49.0)	40 (25.5)	138 (38.7)	<0.001
Weekend	102 (51.0)	117 (74.5)	219 (61.3)	
<sup>a</sup> Season				
Spring	86 (43.0)	83 (52.9)	169 (47.3)	0.064
Summer	114 (57.0)	74 (47.1)	188 (52.7)	
<sup>a</sup> Gender				
Girls	106 (53.0)	63 (40.1)	169 (47.3)	0.016
Boys	94 (47.0)	94 (59.9)	188 (52.7)	
<sup>a</sup> Age				
5-6	n=159* 65 (40.9)	n=111* 46 (41.4)	n=270* 111 (41.1)	0.497
7-8	57 (35.8)	31 (27.9)	88 (32.6)	
9-10	37 (23.3)	34 (30.6)	71 (26.3)	
<sup>a</sup> Race/Ethnicity				
Asian	n=192* 53 (27.6)	n=142* -	n=334* 53 (15.9)	<0.001
Black	17 (8.9)	79 (55.6)	96 (28.7)	
Latino	97 (50.5)	41 (28.9)	138 (41.3)	
White	10 (5.2)	13 (9.2)	23 (6.9)	
Other	15 (7.8)	9 (6.3)	24 (7.2)	
<sup>b</sup> Device measurements		Mean (SD)		
Wear time minutes	29.0 (11.0)	27.0 (12.0)	28.0 (11.0)	0.006
Activity counts per minute	2,011.8 (1,228.0)	2,352.9 (1,336.5)	2,160 (1,285.4)	0.005
Number of steps per minute	39.2 (15.9)	44.8 (25.6)	41.9 (20.3)	0.585
Distance per minute in meters	19.2 (6.0)	25.4 (16.0)	22.4 (12.0)	<0.001
<sup>b</sup> Physical activity levels		Mean (SD)		
Sedentary				
Minutes	2.5 (4.1)	1.8 (2.8)	2.2 (3.6)	0.115
%	8.5	7.0	7.7	0.255
Light				
Minutes	18.2 (8.6)	15.3 (9.4)	16.9 (9.0)	<0.001
%	61.9	56.8	59.9	0.002
MVPA				
Minutes	8.7 (8.0)	9.8 (7.5)	9.2 (7.8)	0.066
%	29.6	36.3	32.4	0.004

Notes: N = total number of children monitored. SD = standard deviation. MVPA = moderate and vigorous physical activity. \*Age and race/ethnicity present smaller sample values due to missing data.

<sup>a</sup>Chi-Square Test, sig. <0.05. Comparison between NY and NC on day of the week, season, gender, age, and race/ethnicity.

<sup>b</sup>Kruskall-Wallis Test, sig. <0.05. Significant differences in mean values between regions (NY and NC).

**Table 5.3. Mean percentage of minutes of physical activity per intensity considering temporal and individual characteristics.**

Mean Percentage of Physical Activity Levels																							
		NY (n=200)						NC (n=157)						Total (n=357)									
		Sed		Light		MVPA		Sed		Light		MVPA		Sed		Light		MVPA					
Day of the Week		Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD	Mean %	SD				
Weekday		7.8	10	60.6	20	31.6	23	5.2	9	53.9	18	40.9	22	7.0	10	58.6	20	34.3	23				
Weekend		8.3	14	64.3	20	27.4	21	7.3	10	55.7	22	35.3	24	7.8	12	59.7	22	31.6	23				
Season																							
Spring		6.9	8	66.5	20	26.6	22	5.5	9	52.0	22	40.1	25	6.2	8	59.4	22	33.2	24				
Summer		8.9	15	59.4	20	31.6	22	8.1	10	58.9	20	33.0	22	8.6	13	59.2	20	32.2	22				
		p=.015																					
Gender																							
Girls		9.9	14	65.3	18	24.8	20	7.6	10	59.7	22	29.6	23	9.0	13	63.2	20	26.6	21				
Boys		6.0	10	59.2	22	34.7	24	6.2	9	52.3	20	41.5	23	6.1	10	55.8	21	38.1	24				
		p=.003		p=.033		p=.003				p=.016		p=.002		p=.003		p<.001		p<.001					
Age																							
5-6		8.1	11	67.4	20	24.5	22	5.9	8	56.2	19	37.9	21	7.2	10	62.8	21	30.0	23				
7-8		6.6	11	61.0	20	32.3	22	4.2	8	47.9	18	47.9	22	5.8	10	56.4	20	37.8	23				
9-10		9.1	16	59.0	19	31.8	21	8.6	10	57.3	23	34.2	27	8.9	14	58.2	21	33.0	24				
		p=.034																					
Race/Ethnicity																							
Black		5.5	6	62.0	18	32.5	20	8.0	10	58.9	18	33.0	21	7.6	10	59.5	18	32.9	21				
Asian		10.2	17	63.1	22	26.6	24	-	-	-	-	-	-	10.2	17	63.1	22	26.6	24				
Latino		6.9	11	60.7	20	32.4	22	4.4	7	49.1	25	44.0	28	6.2	10	57.3	22	35.8	24				
White		11.7	14	77.3	18	11.0	18	7.9	9	62.8	18	29.3	18	9.6	11	69.1	19	21.3	20				
Other		7.6	10	58.3	17	34.1	21	7.6	10	43.2	8	49.2	11	7.6	10	52.7	16	39.8	19				
		p=.008						p=.015						p=.026						p=.021		p=.003	

Notes: N = total number of children monitored. SD = standard deviation. Sed=Sedentary behavior. MVPA = moderate and vigorous physical activity. Age and race/ethnicity present smaller sample values due to missing data.

Kruskall-Wallis Test, sig. <0.05. Significant differences in mean percentage values between categories, independent from region.

The mean percentage of minutes spent in each of the physical activity levels appears in Table 5.3. In NY, the average proportion of light activity was lower in the summer (59.4%) when compared to the spring (66.5%) ( $p=0.015$ ). No other proportions were significantly different when comparing day of the week and season in both regions.

Overall, girls were more sedentary than boys (9.0% vs 6.1%, respectively;  $p=0.003$ ). Girls, on average, had higher proportions of light activity (63.2%) when compared to boys (55.8%). Boys, on average, spent a higher proportion of time in MVPA (38.1%) than girls (26.6%). In NC, MVPA was higher in proportion for 7-8-year-olds (47.9%) when compared to younger (37.9%) and older children (34.2%) ( $p=0.034$ ).

There were differences in proportion of MVPA when stratifying by racial/ethnic groups ( $p=0.003$ ). The average proportion of time spent in MVPA was higher for youth who were parent-identified as Black (32.9%), Latino (35.8%), and Other (39.8%) compared to Asian (26.6%) and White youth (21.3%). This was also the case in NY, where youth who were parent-identified as Black (32.5%), Latino (32.4%) and Other (34.1%), on average spent a larger proportion of time in MVPA than Asian (26.6%) and White youth (11.0%) ( $p=0.008$ ). In NC, parent-identified Latino (44.0%) and Other (49.2%) participants spent a higher proportion of time in MPVA than Black (33.0%) and White (29.3%) participants ( $p=0.026$ ).

**Table 5.4. Total minutes and proportion of MVPA within park features in 12 neighborhood parks in NY and NC.**

Type of feature	Minutes of activity per feature types								
	NY			NC			Total		
	Total minutes	Minutes in MVPA	%minutes in MVPA	Total minutes	Minutes in MVPA	%minutes in MVPA	Total minutes	Minutes in MVPA	%minutes in MVPA
Ball court	132	38	29%	215	85	39%	347	123	35%
Ball field	74	34	45%	299	97	32%	374	131	35%
Basketball court	216	93	43%	225	108	48%	442	201	45%
Games	48	20	41%	12	6	52%	60	26	43%
Open space	-	-	-	115	41	36%	115	41	36%
Playground set	2,163	718	33%	1,187	446	38%	3,350	1,164	35%
Splash pad	666	179	27%	-	-	-	667	179	27%
Swing set	445	221	50%	490	208	42%	935	429	46%
Other	1,816	436	24%	1,640	526	32%	3,456	963	28%
<b>Total</b>	<b>5,560</b>	<b>1,739</b>	<b>31%</b>	<b>4,184</b>	<b>1,517</b>	<b>43%</b>	<b>9,744</b>	<b>3256</b>	<b>33%</b>

Notes: MVPA = moderate and vigorous physical activity.

A total of 38,978 GPS/accelerometer points at 15-second epochs generated 9,744 minutes of activity, an average of 27.3 minutes per participant (Table 5.4). Over 35% of total minutes captured by accelerometer and GPS were outside of predetermined areas. Playground sets had the highest total minutes and MVPA minutes in both regions, 33% in NY and 38% in NC. In NY, features with the highest proportions of MVPA were swing sets (50%), ball fields (45%), basketball courts (43%), and games (41%). In NC, features with highest proportions of MVPA were games (52%), basketball courts (48%), and swing sets (42%). Though total minutes in areas outside of mapped features was high, only 24% of the time spent in Other was in MVPA in NY, and 32% in NC.

## Discussion

On average, children spent 32.4% of time being moderately active in the parks. Children spent 35.5% of the average 28 minutes during which they were monitored in the park in areas that were outside of the predetermined physical activity target areas. Swiss children who were

monitored with GPS and accelerometer spent only 17% of their time in MVPA while in parks, equivalent to nine minutes of park-based physical activity (Bürge et al., 2016). A North American study with children aged 8-14 years old reported that, when they spent 15 or more minutes in the park, park-based MVPA increased as a proportion of time (Dunton et al., 2014). As we required participants to wear the devices for at least 15 minutes, our higher percentage of MVPA could be due to the demand in park stay. It is important to note that even though NY participants wore devices for longer than those in NC, they did not have significantly more park-based MVPA in minutes. Instead, light activity increased.

Regarding seasonal differences in levels of physical activity, proportions of light activity were higher during spring (66.5%) when compared to summer (59.4%) in NY. Inversely, sedentary time as well as moderate and vigorous activity were lower in spring and increased during summer. One hypothesis is that the hot weather could be playing a role. Further, there are reasons to believe that the common lack of structure of the summer may lead to these fluctuations in active behavior. A literature review identified studies from 2005 to 2013 that indicated the summer time (or “off school”) as having a negative effect on children’s activity, leading to weight gain. This was found to be especially true in majority Black children, Hispanic children, and overweight children (Franckle et al., 2014). Although the reasons for weight gain were not clearly specified in the literature review or the studies included in it, decreased physical activity and increased sedentary behavior, as well as unstructured schedules were some of the assumptions made by researchers. The “Structured Days Hypothesis” was founded on the idea that a structured day, such as those during school time in spring, play a protective role for children against so-called obesogenic behaviors. The lack of structure during summer days could result in weight gain and decreases in cardio-respiratory fitness (Brazendale et al., 2017). Another study of 205 minority youth indicated

less physical activity and more screen time in the summer (Sallis et al., 2019). One potential reason why NC did not see the same differences in activity between spring and summer is because some schools in NC follow a year-round model thus children could be either in school or on break during both seasons. This was tested in a study of year-round and traditional schools with elementary age children (5-12 years old) where traditional school children experienced more unhealthy changes (Weaver et al., 2020). Thus, the lack of structure during summer has a known negative impact on children's behavior and that might be translated to the park environment as well.

Differences in physical activity between girls and boys were expected due to extensive previous research (The Lancet Public Health, 2019). We found that girls had more sedentary time and light activity than boys. Boys spent over 30% of their time in the park in MVPA. Since average wear time was similar for girls and boys, more MVPA by boys meant more sedentary and light activity by girls. This is in agreement with an international study of children's physical activity and sedentary time, which assessed objectively measured data from 27,637 participants in 10 countries and found that boys were, indeed, more active and less sedentary than girls at all ages (Cooper et al., 2015). A study in Denmark using a similar measurement approach identified children's locations for activity, including sports clubs, school grounds, and sports facilities, among others. During a regular day, boys were found engaging in MVPA almost 20 minutes more than girls in 10 out of the 15 contexts investigated (Klinker et al., 2014). However, there were no gender differences when MVPA was in playgrounds and urban green spaces, which could mean these park features could be a strategy to reduce the gender gap in physical activity. In the Netherlands, schoolyard activity was studied in 257 children 8-11 years old (Van Kann et al., 2016). Boys consistently had more MVPA minutes than girls and girls had more sedentary minutes than boys. One possibility for why this difference occurred is that the features girls choose to use

while in the park may be those promoting more sedentary or light activities, while boys prefer features often used for MVPA. Some of our previous work suggests that girls used more playground sets, swing sets, and splash pads; boys were more often observed in courts and fields, which are naturally conducive of active play (Alberico, 2021). Researchers have reported that girls had higher odds of being active when other active children were present (Bocarro et al., 2015).

Our majority Black, Latino, and Other race/ethnicity groups had higher proportions of time spent in MVPA. It is possible that more activity by participants is a reaction: once in parks where their race/ethnicity is a majority, there is representation, which in turn leads to being more confident (Horcajo et al., 2010). Moreover, parks seem to be of unequal access and quality in neighborhoods where minority groups reside (Powell et al., 2004). Perhaps this is what these communities require to engage in higher levels of physical activity. Our data revealed high levels of MVPA by children of racial/ethnic minorities. Additionally, the concept of super diversity in public health highlights the emergence of a challenge that includes categorizations in race and ethnicity (Phillimore et al., 2019). When survey categories are restricted to only a few options, the “other” category may outnumber some of the existing categories. Our “Other” included any other option with which a participant identified and those who identified as more than one race/ethnicity, even if those were in the categories offered. However, some of the participants who presented higher proportions of MVPA could have been classified as one of the other race/ethnicity categories, which could have made the differences less spread throughout the categories.

We found that swing sets, basketball courts, and games were the park features with the highest percentage of participant time in MVPA (over 40%). These results are like those from another previous report of ours in which, using direct observation, we showed 75% of the MVPA was achieved in those same features and that playgrounds also had a high proportion of time in

MVPA, with over 55% of participants being observed in those activity levels (Alberico et al., 2021). A national study of neighborhood parks reported that almost 50% of playground use was in MVPA (Evenson et al., 2019). Evenson and colleagues found that playground sets had a large amount of participant minutes but only 35% of that time was in MVPA. Using direct observation to assess park use and physical activity limits the findings to specific target areas, defined by features that can be used for physical activity. We were able to determine that over 30% of total location points were outside of any pre-determined activity area, with an average 28% of the participant time in MVPA spent in such areas. This finding provides evidence that there are areas in parks that are being highly used, though compared to other defined activity spaces (e.g., swing sets and basketball courts) the proportion of time in MVPA for this feature is less. This may be due to the bias from following the SOPARC protocol: by only measuring active spaces and often removing spaces such as benches and tables from observations, SOPARC also often removes sidewalks and walkways between activity features from observations, so there should be assessment of these spaces. There is a potential for activating these in-between spaces through programming and temporary equipment.

We are one of the few to use accelerometer and GPS to identify use of parks and park-based physical activity. To our knowledge, we are the first to recruit participants *in situ* for a determined period while in the park. We found children to be in MVPA 32.4% of the time, which is less than others using SOPARC have reported, 47% of whose children participants observed were engaging in moderate and vigorous activity (Evenson et al., 2019; Floyd et al., 2011; Alberico et al., 2021). Differences in proportion in MVPA are potentially due to the methods used. Accelerometers provide counts that can be later processed to determine activity intensity, while SOPARC often depends on the perception of the observer. Even though accelerometers can

provide more accurate information on movement, the selection of cut-points to determine activity intensity can be a challenge. Evenson et al. (2008), who studied 5-8 year old children, suggested that age-specific accelerometer cut-points were not needed for this age group, despite the fact that others argue that such specificity is, in fact, needed (Sirard & Slater, 2008).

### ***Limitations and Strengths***

We are one of the few to monitor children's physical activity and use of space using GPS and accelerometers while in parks. We are the first to propose collecting data in the park during children's free play and to assess their use of park features and its association with physical activity intensities. We employed a cross-sectional study design, which cannot be used to detect causal relationships. Though there was a distribution between seasons and days of the week, the limited number of researcher visits is a limitation that must be taken into consideration. Although ours is a novel protocol, this limits the understanding of the global physical activity levels for the children. Moreover, we selected participants who were already users of parks, which limits our understanding of what could be done to improve park use by those who are not park users. The minimum 15 minutes use of monitors did not necessarily correspond to the duration of a participant's entire park visit, which we could not identify. Future studies could continue to recruit participants in parks and extend their participation throughout a week to provide a broader understanding of children's physical activity.

The delimitation in neighborhood type by socioeconomic status and race/ethnicity majorities is a strength of our study because we prioritized populations, on average, facing greater health inequities. However, we cannot compare park-based MVPA across neighborhood income

stratification. A wider range of neighborhoods should be included in future studies to better identify patterns of park use and activity that may be associated with socioeconomic status.

Another strength of our study was the use of accelerometer and GPS devices to objectively measure spatial locations and activity intensities during park visits, making it possible to describe objectively the use of park features and park-based physical activity. The time spent in the different intensities of physical activity may have been affected by the choice of cut-points for accelerometer processing, as there are a plethora of options, none of which match the 15 second epochs we used (Mota et al., 2007; Thiese et al., 2014). Age specific cut-points are rare and for the age range we used they have not been well established. Future studies should compare different cut-points to better identify intensity in shorter epoch lengths and at specific ages.

### ***Conclusions and implications***

In this paper we described 5-10-year-olds' physical activity and use of park features in two regions of the U.S., in a total of 12 parks in low-income, diverse neighborhoods. The children wore GPS devices and accelerometers for an average of 28 minutes per child. More participants were sampled on weekends compared to weekdays. Of the time children were monitored while within parks, they were in light activity 60% of the time. More than 30% of the remaining time was spent in MVPA, meaning only 10% of time was sedentary, on average. Girls spent more time in either sedentary behaviors or in light activity while boys spent more time in MVPA. There were differences in MVPA by race/ethnicity; children who were parent-identified as Black and Latino were more active, on average, with higher proportions in MVPA than other race/ethnicity groups. Playgrounds and other features had more minutes of use, but swing sets, games, and basketball courts had the highest proportions of MVPA.

Using GPS devices and accelerometers to capture the use of space as well as the physical activity intensities achieved during children's park visits, we identified that most of participant time was spent engaging in light activity (60%). MVPA comprised 32% of time spent in these settings. Even though the amount of monitoring time was similar, boys were more active than girls. We found a large proportion of location points outside of traditional features and most of participant time in MVPA was spent in basketball courts, games, and swing sets (40%+).

These findings could provide direct implications for park design and management. Parks and Recreation agencies can also benefit from these results to better leverage programming by park user characteristics and temporal patterns, such as the summer, to offer programs that are adequate for the weather at this time of the year. Furthermore, researchers should take heed of the lessons generated from our use of a novel protocol (such as capturing over 35% more information from spaces that were previously ignored) and possibly re-apply it in future research. Additionally, design strategies can be used to provide features that promote more active behavior. The knowledge of the use of park spaces and users' physical activity levels is an asset in activating park areas and in promoting healthy behavior in low-income, diverse communities.

## CHAPTER 6: CONCLUSIONS

Not everyone has the same opportunities for physical activity, an inequity especially concerning for girls, youth of color, and low-income families (Armstrong et al., 2018) despite the fact that active behavior is beneficial for youth (Poitras et al., 2016; Telama et al., 2005). One of the steps in advancing physical activity research has been the focus on the effectiveness of interventions for different age, ethnic, and socioeconomic groups (Lambert et al., 2020) but in order to intervene there is a need to understand active behavior and use of space. Thus, to advance the field, there is a need to develop better study designs and guarantee context specificity (Atkin et al., 2016). There has been key information missing on how youth from diverse backgrounds and neighborhoods make use of spaces for physical activity, including parks.

In this dissertation, I aimed to describe youth spatio-temporal park feature use and park-based physical activity in low-income communities of color. Evidence shows that 30% of park users in the U.S. are youth 19 years old and younger (Evenson et al., 2016; Joseph & Maddock, 2016). When youth are in parks, certain park features are used more than others: playgrounds, open spaces, picnic areas, sports fields, and courts are spaces more often used (Floyd et al., 2011). But the observational studies have been mostly in White communities, or include data without distinction of race/ethnicity or the income of park users and the surrounding neighborhood. Inclusion of race, ethnicity, and income is essential because social injustices have produced inequalities in access to physical activity facilities and the opportunity to be active for these populations. Furthermore, the use of space and the pursuit of activity can be context dependent and it is important to consider culture specific aspects that may increase resilience in these low-income communities of color. My dissertation included the demographic, temporal, and spatial data associated with youth park feature use and park-based physical activity in low-income,

diverse neighborhoods. My results have the potential to inform designers and managers when they design or renovate parks so that their parks may attract youth from all backgrounds.

## **Summary of findings**

### ***Objective 1: To describe the Physical Activity and Recreation in Children in Communities of Color (PARC<sup>3</sup>) Study, a multi-method, multi-site study of parks in low-income communities of color***

My first objective in this dissertation was to describe the framework used in the PARC<sup>3</sup> study to examine the patterns of park use among children from different racial and ethnic groups in low-income neighborhoods. The narrative of my first study sought to highlight the combination of methods employed to study physical activity behavior and the use of public open spaces, here represented by parks. I wanted to understand park use and park-based physical activity in two regions of the U.S., through a closer examination of three cities: New York City (NY), Raleigh, and Durham (NC). I selected the regions based on the diversity of the populations present so that I might identify important challenges and opportunities in low-income communities of color as cultural contexts can be important when considering use of space.

Widely-known, validated tools and protocols were used in PARC<sup>3</sup> (my data source), supporting a need identified by the 2018 National Physical Activity Plan to enhance physical activity surveillance in the U.S. through the use of instrumentation and data collection systems in real-world settings (National Physical Activity Plan Alliance, 2018). I used direct observation methods to assess of park use and physical activity (SOPARC) (McKenzie et al., 2006), park structure and quality (CPAT) (Kaczynski et al., 2012), and neighborhood characteristics (ANC) (Hoehner et al., 2007). This combination of methods enabled me to understand the physical aspects

of the parks and their neighborhoods as well as the parks' social context based on their users and the activities of those users.

This understanding of park use and park-based physical activity depended on the perceived race/ethnicity of park users. Though the original SOPARC protocol includes race/ethnicity (McKenzie et al., 2006), it is rarely used (Evenson et al., 2016). Other researchers have considered how to minimize potential observation errors or biases and agree that the more diverse the observers are, the more reliable they can perceive race/ethnicity in others (Campbell et al., 2020; Harris, 2002). I was very fortunate to count on a great diversity within the research teams both in New York and North Carolina, which may have benefited my results in terms of observation reliability (Marquet, Hipp, et al., 2019).

As we used devices to monitor children's physical activity in parks, the necessity to have bilingual research assistants quickly became apparent as monitoring included consenting and assenting the parent-child dyad and asking the parent/guardian to complete a tablet-based or paper survey. There was a greater number of participants responding to bilingual research assistants compared to those who only spoke English to participants. More information on the challenges we encountered and the insights we gained during data collection can be found in a publication by the larger PARC team (Botchwey et al., 2020)

The challenges and opportunities from the PARC<sup>3</sup> study can be used to rethink strategies for data collection, data processing, and data analysis that can in turn lead to a more robust dataset which will benefit future researchers. It is an expectation that, due to its originality, the protocol we followed to obtain spatial and behavioral data inside particular settings (i.e., monitoring data) will be useful and improved with further implementation. In summary, the following are the main messages from my first study:

- ✓ The use of a combination of methods is feasible to assess use of space and physical activity behavior in low-income communities of color;
- ✓ Observers must be well-trained and preferably of diverse backgrounds to reduce bias in perceived demographic variables;
- ✓ The use of race/ethnicity in systematic direct observations with SOPARC can be of importance if the research question determines it to be consequential. Reliability can be improved by having diverse observers; and,
- ✓ Cultural context is important and must be considered when conducting research in diverse communities: using the community's language, providing incentives, and community engagement are essential.

This objective described a protocol that highlights the need for diverse researchers to investigate diverse communities. It also reinforces the need to have community engagement when collecting data so that low-resourced communities are not further challenged (and possibly offended) by extraction, but are a part of the evaluation process and thus hopefully may further benefit from evaluation and research results as well as opportunities. Researchers and managers may be able to decide which methods and protocols to use based on these findings. In the future, how can we make methods and protocols available for practitioners?

***Objective 2: To describe youth use of features by demographic (age, gender, race/ethnicity), physical activity (sedentary, moderate, and vigorous), and temporal (time of the day, day of the week, and season) characteristics within low-income, diverse neighborhood parks***

My second objective in this dissertation was to understand how park features are used by youth in low-income, diverse neighborhoods. Using the PARC<sup>3</sup> systematic observation data obtained via SOPARC, I described youth use of features stratified by demographics, temporal

characteristics, and physical activity levels. As these are observations of places, park feature use is the unit of analysis for this part of my dissertation. Park features were classified into eight types: ball courts, ball fields, basketball courts, games, open spaces, playgrounds, swing sets, and splash pads. Youth were observed and counted in each of the feature types according to observer perceived gender, perceived age, and perceived race/ethnicity. All observations were completed in 5,881 hours and over 41,410 youth were observed. Overall reliability was 75% for New York and 82% for North Carolina, both considered good (Marquet, Hipp, et al., 2019b). Swing sets were the park features most used by girls while basketball courts were the features most used by boys. Playground sets and splash pads were used similarly by children of both genders. We found that the majority of youth perceived as Asian and Black were more prevalent and more active in basketball courts while youth perceived as Latino were more prevalent and active in ball fields.

Though a large number of hours were covered, youth were observed only 50.9% of the time (or, for 2,999 hours). Open spaces were often (90% of the time) empty. Ball courts, ball fields, and games also were mostly empty. Most likely, spaces like ball courts and fields are used for organized sports, which may be taking place at specific times that were not in our study schedule. When there are few youth in the park, they seem to be less likely to occupy spaces that are intended for larger team sports (e.g., baseball, softball, and soccer).

Importantly, the SOPARC method targets specific areas to be observed. Although a large number of the observations across the 40 parks were empty, there is a possibility that youth were present in other areas of the park that were not captured by the SOPARC protocol. This is a limitation that must be taken into account when using this method for surveillance of spaces, as suggested by my findings in the first study in my dissertation. The multi-method approach of

PARC<sup>3</sup> has the potential to overcome that limitation by the use of devices which I will discuss in the third and final objective.

The lessons learned from the second study in my dissertation can be summarized as follows:

- ✓ Park features in low-income communities of color were used differently by youth according to observer perceived age, perceived gender, and perceived race/ethnicity;
- ✓ Youth were mostly engaged in moderate physical activity while in features within low-income neighborhood parks in communities of color;
- ✓ Almost 50% of the time, park features were empty, suggesting the need for evidence that can show whether youth might be present in spaces other than park features;
- ✓ The use of park features in each neighborhood presented unique aspects since parks did not have the same set-up; and,
- ✓ There is a need for culturally responsive design to serve the needs of low-income communities of color.

Through the work I performed to accomplish this objective, there is clear evidence of park feature use which could inform park design and management. By building and maintaining spaces that are preferred or used more by youth of color, we may be able to promote park use and physical activity (possibly into adulthood), thereby reducing health disparities. Spaces that offer opportunity for activities where children feel like they belong, such as those in their own neighborhoods, need to be a priority. Further, is it possible that the presence of others would

change how children behave in park features? And are the conditions of the features of importance to how children use them and the physical activity they engage in when in those features?

***Objective 3: To describe 5-10-year-olds' physical activity by individual (age, gender, race/ethnicity), temporal (day of the week and season), and spatial characteristics within low-income, diverse neighborhood parks***

In my third and final objective for this dissertation I sought to expand on the previous objective by understanding youth park use from the perspective of the user, i.e., the participant (n=357) was the unit of analysis for this objective. My main goal was to use monitoring devices, GPS and accelerometers, as a solution to the limitations found when using systematic direct observations and the SOPARC protocol (Dunton et al., 2014; Evenson et al., 2013).

I used data from the monitoring phase of PARC<sup>3</sup> to describe 5-10-year-olds' park-based physical activity, stratified by parent/guardian-reported demographics (gender, age, and race/ethnicity), day of the week, and season. I identified that most of the participants' time was spent engaging in light activity (60%). Of the total time spent in the park, children were engaged in MVPA for 32% of the time. Girls had a higher proportion of sedentary time and light activity than boys. Boys, on the other hand, had a higher proportion of moderate and vigorous physical activity. Non-White racial/ethnic groups spent higher average proportions of their time in MVPA than White children.

At least 40% of participants' minutes in MVPA were spent in basketball courts, games, and swing sets. Over 30% of the time spent by children in low-income neighborhood parks were in spaces that were not previously identified as park features, i.e., children spent one third of their

time between features or in areas that were not mapped for direct observations. The summary of key points for this objective includes the following:

- ✓ Children spent one third of their time being moderately active;
- ✓ Girls had more sedentary time and light activity than boys. Boys had greater proportions of time spent in MVPA;
- ✓ Moderate to vigorous activities were mostly performed in basketball courts, games, and swing sets;
- ✓ The use of monitoring devices is a potential solution to capture data from all park spaces and eliminate observer bias; and,
- ✓ My results may need to be stratified by neighborhood park to examine their robustness since they may be dependent on context;

The evidence I documented in this part showed that one third of children's time in parks was spent in MVPA. Neighborhood parks where non-White children were the majority could contribute to elevated levels of physical activity. Moving forward, how can we make children's time spent in parks be more active than not? And how could we attract other children to the park?

### **Methodological considerations**

I used well-established methods to obtain spatial and user data from within low-income, diverse neighborhood parks. The methods can be employed to identify park feature use, and have direct implications for park planners as well as designers in creating spaces for active behavior in a community (Kaczynski et al., 2008). Through direct observation (SOPARC) and objective device measurement (GPS and accelerometer), I created two datasets. The first dataset contained space characteristics as the unit of analysis. The second dataset comprises spatial characteristics

aggregated to human behavior. The methods I used to create both datasets can generate answers to questions similar to those in this dissertation, each with their own opportunities and limitations. The choice of method for assessment of parks should be based on the specific needs and resources available.

The use of SOPARC to assess park space use and physical activity levels requires well-trained observers (Campbell et al., 2020; Harris, 2002) for both the traditional pen-and-paper version or the electronic format (Santos et al., 2016). The benefits of using the traditional format include adjustments made to the SOPARC form and protocol to better adapt SOPARC to a researcher's needs. Other researchers conducting studies similar to PARC<sup>3</sup> have made modifications to the original protocol (e.g., Bocarro et al., 2009). Nonetheless, many researchers have used SOPARC in its original format for surveillance of physical activity which permits direct comparisons of their results (Chow et al., 2016; Cohen et al., 2012, 2014, 2015; Cohen, Han, Nagel, Harnik, McKenzie, et al., 2016; Floyd et al., 2011; Lindberg & Schipperijn, 2015; Parra et al., 2010; Schultz et al., 2016). The SOPARC tool was developed to assess specific areas of interest, recording who is there and what is happening during the momentary scan (McKenzie et al., 2006). SOPARC thereby provides a snapshot of the area, which is the most common unit of analysis in SOPARC studies.

On the other hand, the use of devices is advancing the field of physical activity and environment research (Beeco & Brown, 2013; James et al., 2016; Jankowska et al., 2015; Rodríguez et al., 2005; Terrier et al., 2000; Troped et al., 2010) as it allows the capture of participant behavior (i.e., movement) and location simultaneously, without depending on recall or the potentially biased observations of a human being who may overestimate physical activity. But such use does come with a cost. The devices used in the PARC<sup>3</sup> project have an approximate cost

of US\$300 per set of accelerometer and GPS. Additionally, specialized software and knowledge are required to program the devices, download their data and process the data into the variables used for analysis. So, although the cost is high, the benefit is the physical activity data and geographic position information obtained at the individual level by these devices which allows a more precise understanding of behavior and space by determining where the participant has been and at what level of activity they were. Added to self-reported demographics, we are able to answer questions regarding the who, what, where, and when of physical activity and space.

With regard to both methods, the following points must be made. First, the adaptation of the SOPARC form allowed our research team to transform the unit of analysis from the observed area to the participants. Using an automated system, users within a category of gender, age, race/ethnicity, and physical activity were transposed in the database and then duplicated the number of times equivalent to the number of observed individuals, creating a dataset where participants were the unit of analysis. This is a novelty in the use of SOPARC, where the original protocol can not connect all the variables as we did. Second, the use of GPS and accelerometer to assess parks and children's behavior, to our knowledge, had not been studied previously.

A summary of the results delivered by each of the methodologies appears in Table 6.1. Direct observations identified park features that were used the most and the least, with usage data separated by gender, age, and race/ethnicity. The level of observation and analysis was the park feature. As the data was stratified by city and neighborhood, the results were presented also according to neighborhood characteristics. For example, girls were mostly present in swing sets in majority Asian neighborhoods and majority Latino neighborhoods in New York City, meaning that the highest proportion of girls was observed in the swing set area (or feature).

Monitoring, on the other hand, was able to identify the proportion of sedentary or moderate and vigorous activity performed by individual participants, and in aggregate, e.g., summed by gender, age, and race/ethnicity. The level of analysis was the individual and their intensity of movement, i.e., for children ages 5-10 (the only group assessed with devices), for example, 35% of their time was spent in MVPA and 6% was sedentary time. Thus, within my dissertation, the first method presents results in terms of use of space while the second focused on physical activity intensity. Nonetheless, there is an opportunity for data analysis that goes beyond the scope of my dissertation. Such monitoring data should be processable, in the future, to identify intensity of activity and location at the same time.

When the results were stratified by park feature, similar variables were available from both methods: proportion of feature use and proportion of time in MVPA. However, the measure of physical activity varied by method. *Perceived* activity in direct observations could be classified into sedentary, moderate or vigorous, as determined by the observer. For accelerometer-measured activity, through data processing we obtained *objective* activity intensity based on counts, using cut-points previously established and presented in this manuscript, with the potential categories being sedentary, light, and moderate to vigorous. When comparing results from the two methods, I find interesting the fact that the proportions of MVPA are not at all similar between the two methods and within the park features. For example, basketball courts were being proportionately used 21% of the time with observations and 4.5% of the time with devices. In the same feature, 77% of the children were *observed* in MVPA but 45% of participants' time was *spent*, according to the devices, in MVPA in basketball courts. This may be because observations provide the proportion of children in MVPA within features (that is, what percent of all children were observed

in MVPA) while monitoring provides the proportion of individual physical activity within park features (that is, the average amount of time spent in MVPA by participants).

Importantly, the data obtained from direct observations included youth from 0 to 19 years old while accelerometer-measured results corresponded to participants 5-10 years old. As monitoring devices are objective and unbiased, it is possible to come to the conclusion that direct observation may be overestimating participants physical activity intensities. An opposing possibility is reactivity bias, that those wearing the accelerometers were more active as they were aware, and thus reactive, to wearing the device, i.e., they were more active than usual because they knew they were being monitored for activity.

In terms of proportion of time spent in physical activity, direct observations account for the proportion of all persons observed within a park feature. Monitoring results present the average proportion of time spent in MVPA from the total wear time provided by a certain participant 5-10 years of age. The spaces between features could not be captured by the direct observations, but added an average of 30% more data to the monitoring dataset.

**Table 6.1. Summary of results from assessment of children’s physical activity in parks, according to the methodology used.**

PER USER CHARACTERISTICS					
		DIRECT OBSERVATION		MONITORING	
		Most used feature <sup>a</sup>	Least used feature <sup>b</sup>	% MVPA <sup>c</sup>	% Sedentary <sup>d</sup>
<b>Overall</b>		Playground set (70%)	Open space (10%)		
Gender	girls	Swing set (56%) <sup>Δ</sup> Swing set (65%) <sup>β</sup> Games (55%) <sup>Φ</sup> Games (62%) <sup>Ω</sup>	Basketball court (9%) <sup>Δ</sup> Basketball court (9%) <sup>β</sup> Basketball court (11%) <sup>Φ</sup> Basketball court (9%) <sup>Ω</sup>	26.6	9.0
	boys	Basketball court (91%) <sup>Δ</sup> Basketball court (91%) <sup>β</sup> Basketball court (89%) <sup>Φ</sup> Basketball court (90%) <sup>Ω</sup>	Swing set (43%) <sup>Δ</sup> Swing set (35%) <sup>β</sup> Games (45%) <sup>Φ</sup> Swing set (37%) <sup>Ω</sup>	38.1	6.1
Age	0-4yo	Swing set (37%) <sup>Δ</sup> Playground set (27%) <sup>β</sup> Splash pad (33%) <sup>Φ</sup> Playground set (22%) <sup>Ω</sup> Games (68%) <sup>Δ</sup>	Basketball court (1%) <sup>Δ</sup> Basketball court (1%) <sup>β</sup> Basketball court (3%) <sup>Φ</sup> Basketball court (2%) <sup>Ω</sup> Ball court (21%) <sup>Δ</sup>	-	-
	5-10yo	Playground set (63%) <sup>β</sup> Playground set (73%) <sup>Φ</sup> Games (81%) <sup>Ω</sup>	Basketball court (35%) <sup>β</sup> Basketball court (27%) <sup>Φ</sup> Basketball court (17%) <sup>Ω</sup>	35.0	6.0
	Teens	Basketball court (74%) <sup>Δ</sup> Basketball court (64%) <sup>β</sup> Basketball court (70%) <sup>Φ</sup> Basketball court (81%) <sup>Ω</sup>	Playground set (9%) <sup>Δ</sup> Playground set (10%) <sup>β</sup> Playground set (8%) <sup>Φ</sup> Games (10%) <sup>Ω</sup>	-	-
Race/Ethnicity <sup>1</sup>	Asian youth	Playground set/Basketball court (68%) <sup>Δ</sup> Games (20%) <sup>β</sup> Basketball court (9%) <sup>Δ</sup>	Ball field (34%) <sup>Δ</sup> Ball court (1%) <sup>β</sup> Games (1%) <sup>Δ</sup>	26.6	10.2
	Black youth	Basketball court (62%) <sup>β</sup> Basketball court (85%) <sup>Φ</sup> Basketball court (90%) <sup>Ω</sup> Games (44%) <sup>Δ</sup>	Ball field (3%) <sup>β</sup> Ball court (26%) <sup>Φ</sup> Ball field (63%) <sup>Ω</sup>	32.9	7.6
	Latino youth	Ball field (84%) <sup>β</sup> Ball court (40%) <sup>Φ</sup> Open space (25%) <sup>Ω</sup> Ball field (22%) <sup>Δ</sup>	Playground set/Basketball court (17%) <sup>Δ</sup> Games (33%) <sup>β</sup> Basketball court (5%) <sup>Φ</sup> Basketball court (8%) <sup>Ω</sup> Ball court (5%) <sup>Δ</sup>	35.8	6.2
	Other youth	Swing set (10%) <sup>β</sup> Ball field (48%) <sup>Φ</sup> Ball field/Playground set (14%) <sup>Ω</sup>	Ball court/Basketball court (1%) <sup>β</sup> Basketball court/Open space (9%) <sup>Φ</sup> Basketball court (2%) <sup>Ω</sup>	30.8	8.6

**Table 6.1 (continued)**

PER PARK FEATURE				
	% Perceived MVPA <sup>2</sup>	% Feature Use	% Accelerometer-measured MVPA <sup>3</sup>	% Feature Use
<b>Overall</b>	71	100	33	100
Ball court	60	9.9	35	3.6
Ball field	60	6.6	35	3.8
Basketball court	77	20.8	45	4.5
Games	75	3.4	43	0.6
Open space	38	0.8	36	1.2
Playground set	63	36.3	35	34.4
Splash pad	62	5.6	27	6.8
Swing set	75	16.6	46	9.6
Other	-	-	28	35.5

Notes: results are presented for four neighborhood types, each representing the majority population through U.S. Census block groups: in New York, <sup>Δ</sup> majority Asian and <sup>β</sup> majority Latino; in North Carolina, <sup>ϕ</sup> majority Black and <sup>Ω</sup> majority Latino. <sup>1</sup>Race and ethnicity were perceived by the observer in direct observations; the same variable was reported by a parent/guardian during monitoring.

<sup>a</sup>Most used feature = feature with the highest proportion of children present during observation in any given category; <sup>b</sup>Least used feature = feature with the lowest proportion of children present during observation in any given category;

<sup>c</sup>%MVPA = average proportion of participants' time spent in MVPA in any given category; <sup>d</sup>%Sedentary = average proportion of participants' time spend sedentary in any given category. <sup>2</sup>Proportion of counts observed in moderate and vigorous physical activity. <sup>3</sup>Accelerometry measured and processed proportion of time spent in moderate to vigorous physical activity.

### *Method comparison*

Considerations when choosing the methodologies for a study on play space and youth physical activity can be informed by Table 6.2. Based on the costs incurred by the PARC<sup>3</sup> Project, an average of \$45 U.S. dollars per target area would be necessary to carry out direct observations in 40 parks. These would constitute observations of one-hour, three times per day in spring, four days of the week (480) plus two times per day in summer (320). They include 21,820 copies of SOPARC forms (one per target area, per round), one handheld GPS unit, and 800 hours of data collection distributed among several research assistants.

Using monitoring methodology and devices, researchers would spend an average of \$40 U.S. dollars per participant to monitor six parks for a single day in two seasons. Copies include surveys, recruitment control documentation, and consent forms. Equipment includes one handheld GPS unit, ten sets of accelerometer and GPS devices (software included in purchase), and 216 hours of recruitment for four research assistants at a time. Incentives were distributed in the form of a gift card.

For research assistants, using the SOPARC protocol only requires training (no previous experience needed) of the research team to collect data. For data management and analysis, some previous knowledge of research is required. The raw dataset uses the target area as the main unit of analysis, as suggested by the original protocol. However, the dataset can be transposed such that the individual observed is assigned the appropriate space and conditions (e.g., organized, shade), and activity intensity, creating a new dataset where the main unit of analysis is individual counts of observation. On the other hand, the use of accelerometer and GPS technologies (Table 6.2) requires previous knowledge, or at least more extensive and specialized training for the research assistants concerning the devices' functions as well as how to perform (via software) device

preparation for data collection and downloading, along with how to preparation a device for repeat use. Researchers should also be prepared to verify data as part of their quality control procedures. As each device contains a combination of accelerometer and GPS, which collect data on behavior and space, respectively, the monitoring methodology can produce datasets where both physical activity and place are the units of analysis.

The outcomes from both methods are generally different (Table 6.1). Direct observation outcomes are perceived by the observer while monitoring includes a survey so participants can self-report individual characteristics such as age, gender, and race/ethnicity. Direct observations add more information regarding the locations being observed such as conditions of the area and presence of adults watching over children. However, it also adds observer bias. Extensive training for direct observations may solve in great part the observation bias. Monitoring, on the other hand, focuses exclusively on the individual and biases may be more present in terms of participant recruitment and reactivity to wearing the devices as participants know they are being monitored for movement.

**Table 6.2 Comparison between direct observation method (SOPARC) and monitoring (accelerometer and GPS) for cost, requirements, and outcomes.**

	DIRECT OBSERVATION	MONITORING
Cost	SOPARC (n=341 target areas)	Accelerometer and GPS (n=400 participants)
Copies (US\$0.10/page)	US\$2,182 (21,820 sheets)	US\$850 (8,500 sheets)
Handheld GPS (Trimble GeoXT; US\$1,200/unit)	US\$1,200	US\$1,200
GPS (Qstarz 1000X-BT; US\$100/unit)	-	US\$1,000
Accelerometer (Actigraph GT3X+; US\$250/unit)	-	US\$2,500
Research assistants (US\$15/hour)	US\$12,000	US\$6,480
Incentives (US\$10 giftcards)	-	US\$4,000
Total	US\$45/target area	US\$40/participant
<b>Requirements</b>		
Specialized data management	✗	✓
Level of data management	Some previous knowledge	Specific knowledge
Training	Required	Required
Methodology expertise	✗	✓
Specialized software	✗	✓
Data analysis specialist	✗	✗
*Space* as primary unit of analysis	✓	✓
Individual behavior as primary unit of analysis	✗	✓
<b>Outcomes</b>		
Number of *space* users	✓	✗
Number of *space* users per demographic characteristics	✓	✗
Number of *space* users per physical activity level	✓	✗
Individual level demographic characteristics and physical activity level	✓	✓

**Table 6.2 (continued)**

Individual level use of *space*	✗	✓
Perceived user characteristics	✓	✗
Self-reported user characteristics	✗	✓
Perceived physical activity	✓	✗
Accelerometer-measured physical activity	✗	✓
Activity type	✓	✗
Activity intensity	✓	✓
Activity duration	✗	✓
Activity frequency	✗	✗

### Limitations and Future Research

The studies composing this dissertation present limitations. Regions, parks, and populations were determined by the PARC<sup>3</sup> project. Since this dissertation used PARC<sup>3</sup> data as a secondary source of data, it was limited to the measurements and selections pre-determined by the scope of the project.

The high number of empty features during observations can be an issue for data analysis but are important information to determine park use. Children were monitored in 12 of the 40 total parks in the study. Because the goal was to have a sample of at least 20 participants per park, per season, the selection for the monitoring phase was intentional and aimed at parks with a higher density of users and better GPS reception. This alone is an important limitation since it has been shown that children tend to be more active when there are other children in the playground with them (Boonzajer Flaes et al., 2016).

When processing the data resulting from in-park monitoring, other important decisions need to be made such as cut-points for physical activity levels using accelerometers. Studies have tested different cut-points and found those can have a great influence on the results for physical activity in children (Mota et al., 2007). This can be a limitation not only for this study but generally in research with activity monitors, especially with children, where the placement of devices and cut-points are very few and studies do not always agree (McCrorie et al., 2014). For the study presented in this dissertation, the activity counts were combined into 15-second epochs (Evenson et al., 2008).

Other studies using data from PARC<sup>3</sup> such as park quality and neighborhood quality related to park use and physical activity have been published (Fry et al., 2021; Huang et al., 2020). Additionally, other analytical methods are underway focusing on park features and aim to identify spatial clustering of children's park-based physical activity. Using monitoring data and geospatial analytics, the study uses Optimized Hot Spot Analysis to identify statistically significant spatial clusters of high (hot) and low (cold) values of park-based physical activity. Preliminary results of hot spot analysis in parks in majority Latino neighborhoods showed clustering of high activity levels (hot spots) in areas with playgrounds (Figure 6.3). Cold spot (low activity values) clustering occurred in areas also with playgrounds but with more seating available, where parents/caregivers were mostly present. Parks in majority Asian neighborhoods similarly had hot spots in playgrounds, but cold spots were found in splash pads. Additional analysis will include stratification per gender, age, and race/ethnicity. The previously mentioned cluster analysis identifies park features or spaces where physical activity is high or low; that is, it determines as a cluster the regions where activity points present similar values, whether high or low. Nonetheless, there are techniques to identify clustering in behavior, independent from spatial locations.

Two promising directions for future research emerge from the study findings. In light of the spatial clustering of children's activity, further investigations of these patterns are warranted. For example, do patterns of sedentary and active behavior vary by sex, age group, and race/ethnicity groups? Further, do they vary according to the race/ethnicity composition of where the parks are located? A TwoStep Cluster Analysis may be used to reveal groupings (or clusters) that would not be apparent otherwise. This will allow for identifying what individual characteristics may be clustering for sedentary behavior and physical activity levels through a novel analytical approach (Dumuid et al., 2018; Matias et al., 2018). Such questions are significant for programming and research, so activities and interventions may be targeted to the groups that need it the most to increase healthy behaviors (Ells et al., 2018). In the long-term, the combination of spatial clustering and behavior clustering may inform an intervention in parks that could include changes made to the built environment and specific programming and education on health behaviors at the individual level.



**Figure 6.3 Example Hot Spot Analysis output from ArcGIS 20.**

The second approach should consider a multi-level analysis. Referring to the socioecological model previously cited, there are individual, interpersonal, environmental, and political factors that may play an important role in park use and physical activity in communities of color. Multilevel analysis may be the ideal way to understand the many levels of influence present in this dataset since we have neighborhood level variables (city, park neighborhood type), and the individual participants. Therefore, another important remaining question is: What is the

importance of park feature-adjacency for children's physical activity and does it vary by sex? Both observation and monitoring methods can provide data to answer this question. The literature has shown that the characteristics of play settings could enable physical activity (Veitch et al., 2021) and there is an important effect of adjacency in such settings in children 3-5 years old (Smith et al., 2016). The number of adjacent features, type of features, and distance between features can be proxies for feature adjacency. The levels for the linear model include: city, neighborhood by predominant race/ethnicity, and park features. A previous study found a positive interaction in the number of recreation facilities in park zones and formalized and organized physical activity. Furthermore, the authors reported an odds ratio of 1.23 in the likelihood of increased physical activity when children engaged in formal and organized play (Floyd et al., 2011). The expectation would be that there is, in fact, increased physical activity levels depending on the number and type of adjacent features.

### **Implications for Practice and Research**

Describing youth feature use and park-based physical activity in low-income, diverse neighborhoods provided evidence to inform what is essential or preferable when building or renovating a park in communities of color: Playgrounds, Swing sets, Splash pads, and Basketball courts are the areas youth used the most and were more active in throughout the study; activating parks may need to start with the areas within the park that are outside of predetermined spaces for physical activity; cultural and context specificity must be taken into account to better serve low-income communities of color.

Parks and Recreation agencies can benefit from these results to better leverage maintenance, renovation, and programming according to neighborhood demographics and

characteristics. For example, youth were shown to engage in more sedentary behavior during summer, so perhaps programs should be implemented during that time of the year to increase physical activity levels.

From the perspective of design and urban planning, these results can inform which features appeal to different users, to help guide choice of features. The use of features showed to be differentiated between girls and boys, according to age, and for distinct race/ethnicity groups. For example, Playgrounds are well visited by younger children and girls, Basketball courts provide higher levels of physical activity and are often used by boys, teens, and by the majority of Asian and Black youth.

Researchers can benefit from these results in several ways. The multi-method approach has proven beneficial to close gaps in data interpretation. Determining methods that have rigorous criteria and can also be effectively used by communities can leverage research efforts to acquire better data. The knowledge of use of park spaces and physical activity levels is an asset in creating interventions to activate park areas through promoting active, healthy behaviors. Future studies may use the results from this dissertation to tailor interventions that will encourage physical activity in low-income, diverse communities. For instance, activating parks may be a matter of programming activities that will use spaces not often used, such as open spaces.

The lack of access and quality of spaces for physical activity for low-income, diverse populations is a public health issue and highlights social and environmental injustices (Jenkins et al., 2015; Rigolon et al., 2018). Understanding use of parks by children of diverse backgrounds can help tailor parks according to the populations in the communities where they are located. Perhaps designing parks with features preferred by the majority of the neighborhood population will attract residents to these spaces and increase physical activity levels, increasing benefits and

leading to fewer health disparities. By addressing the specificities of feature use and park-based physical activity in these neighborhoods, there is potential to reduce physical activity inequities and increase cultural play space preferences in low-income communities of color.

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