Journal of Infrastructure, Policy and Development 2024, 8(4), 3162.
https://doi.org/10.24294/jipd.v8i4.3162

Article

Effects of urban green space (UGS) quality on physical activity (PA) and health, controlling for environmental factors

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CITATION

Zhang W, Li Y, Guo P, Guo X. (2024). Effects of urban green space (UGS) quality on physical activity (PA) and health, controlling for environmental factors. Journal of Infrastructure, Policy and Development. 8(4): 3162. https://doi.org/10.24294/jipd.v8i4.3162

ARTICLE INFO

Received: 3 November 2023
Accepted: 1 December 2023
Available online: 26 February 2024

Abstract: Recently, there has been a burgeoning fascination with the influence of urban green spaces (UGS) on physical activity (PA) and health. This interest has been accompanied by a mounting body of evidence that establishes a connection between UGS and residents' PA levels. Numerous studies have been conducted to investigate the significance of UGS and have generally agreed on their connection with health. However, there is still considerable variation in viewpoints regarding the intermediate factors contributing to this association. The primary objective of this study was to investigate the potential correlation between different qualitative factors of UGS and PA. The study involved the collection of data from four parks located in Edinburgh. Four trained observers utilised the Environmental Assessment of Public Recreational Spaces (EARPS Mini) tool to code various environmental characteristics. Additionally, the Method for Observing Physical Activity and Wellbeing (MOHAWk) observation tool was employed to code instances of on-site incivility and the characteristics and behaviours of residents engaging in UGS activities. The results of this study show that the facilities and environment, area and socioeconomic status (SES) of UGS positively affect the type of PA and the level of PA, as well as influence residents' attentiveness to the environment and their interactions with each other. Demographics such as gender and age group are also significantly related to the level and type of PA. Significant differences in the level and type of PA, and race only differed significantly in the choice of activity type. These results suggest that the quality of the UGS environment affects the level, type, and status of PA among residents and that resident characteristics also have an impact. Future research suggests increasing data collection related to PA frequency and PA duration and considering longitudinal observations over time for refinement.

Keywords: urban green spaces (UGS); physical activity (PA); environmental factors; socioeconomic status (SES); demographics

1. Introduction

1.1. Chapter introduction

In this chapter, the background of this study is elaborated in depth, including the damage caused by current excessive urbanization to the environment, climate, etc., which in turn affects the health of residents; and the various ways in which UGS affects health levels, etc. Based on the research background, this chapter proposes the objectives and questions of the research. Furthermore, this chapter introduces the significance and value and research structure of this research.

1.2. Research background

1.2.1. Global urbanization issues

The global demographic landscape is currently experiencing a significant shift towards urbanization. At present, approximately 3.4 billion people, accounting for half of the world's population, reside in urban regions (D'Alessandro, 2015). Projections indicate a substantial rise in this proportion, with urban dwellers expected to increase from 46.6% in 2000 to an estimated 69.6% by 2050 (Le et al., 2019). However, this escalating urbanization, coupled with the growing density of urban inhabitants, has given rise to numerous issues. These include expanding social disparities, constrained accessibility to public services, and a noticeable disregard for environmental concerns, all posing a significant threat to city livability (Farkas et al., 2023).

The wave of urbanization is also accompanied by challenges such as environmental degradation, accidents, the heat island effect, and climate alterations (Campbell-Lendrum and Corvalán, 2007). Consequently, there's a globally recognized urgency for implementing cross-sectoral initiatives aimed at safeguarding the health of urban dwellers amidst rapid urbanization (Southern, 2002). Some scholars argue that along with accelerated urbanization comes a heightened demand for leisure activities (Wu et al., 2011). Cities cater to the recreational needs of their swelling populations through the provision of natural spaces. The adverse effects of urbanization, including the degradation of UGS (Kong and Nakagoshi, 2006), continue unabated. Singh et al. (2020) illustrates how this evolution adversely impacts the quality of life and health status of city dwellers.

It's concerning how urbanization negatively influences human health. Highlighting the connection between environmental conditions and health, the World Health Organization in 2010 emphasized the urgency of prioritizing health enhancements via environmental improvements (D'Alessandro et al., 2015). However, with increasing urbanization and densification of spatial planning policies, today's residential and green environments are increasingly separated (Nilsson et al., 2014). Restricted access to green spaces in cities may Exacerbate mental health impairment when people face stressful life events (Pouso et al., 2021).

1.2.2. Ways in Which UGS Affect Health

The impact of UGS on health is influenced by several factors, including reduction of air pollution, relief from stress, promotion of social cohesion, and encouragement of PA. Specifically, green spaces embedded in residential areas can play a key role in reducing air pollution and minimizing the urban heat island effect. The presence of trees and shrubs can regulate air quality, consequently affecting human health and well-being. However, they can paradoxically contribute to air pollution by emitting hydrocarbons, even though they have the potential to lower the levels of pollutants such as gases and particulate matter (Wolch et al., 2014). Additionally, trees within green spaces can cut down on energy usage in buildings, thus enhancing air quality and providing a cooling effect in urban settings (Benjamin and Winer, 1998). It's important to note that the relationship between UGS, air pollution, and health is multifaceted and can't be oversimplified. Research on environmental justice have identified disparities in environmental exposure within

UGS across various demographic groups, including income and race. Specifically, UGS located in low-income areas and areas predominantly inhabited by people of colour have been found to have elevated levels of air pollution. Moreover, individuals engaging in PA within these spaces may experience heightened exposure to pollutants, which can harm their health (Su et al., 2011).

Simultaneously, research indicates that the natural characteristics and open spaces within residential areas hold significant importance in fostering residents' community attachment and interactions with fellow residents, for instance, aiding the development of social cohesion (Kneeshaw-Price et al., 2015). Social cohesion embodies common norms and values, the presence of positive and friendly relationships, as well as a feeling of acceptance and membership. The availability of green space as a communal feature, rather than an individual one, is more likely to influence social cohesion (Kuo et al., 1998). Conversely, overgrown or poorly managed green spaces may increase people's anxiety arising from the fear of crime, thus negatively affecting people's well-being (Kuo and Sullivan, 2001).

As previously noted, UGS can influence residents' health by mitigating life stress. Typically, individuals dwelling in environments with limited green spaces may be more prone to adverse impacts from stress-inducing life events, as they are less inclined to engage with nature-based stress-relief strategies compared to those in greener surroundings (Kondo et al., 2018). Hence, readily accessible green spaces could be a critical environmental aspect defining the link between stressful life events and health. The World Health Organization advocates for creating living conditions and environments conducive to mental well-being and facilitating individuals in adopting and maintaining healthy lifestyles (Dawson et al., 2015). By fostering PA, offering communal gathering spots, encouraging social interaction, and relieving stress, green spaces are believed to benefit mental health (Cohen-Cline et al., 2015).

Furthermore, substantial research supports the assertion that green spaces influence PA, thereby conferring physical and psychological benefits (Morris, 2003). Engaging in PA in green spaces can effectively lower the risk of diabetes, colorectal cancer, depression, osteoporosis, among other diseases (Lee and Maheswaran, 2011). When it comes to mental health, green spaces can foster better mental well-being, enhance cognitive function, and contribute to overall contentment, potentially offering enduring psychological advantages (Gascon et al., 2015). Furthermore, reports suggest that UGS might be positively correlated with extended life expectancy (Sumi, 2016).

1.3. Research objectives and questions

Based on the research background provided in the previous article, it can be learned that UGS affects residents' health in various ways, including reducing life stress, promoting PA, and improving social cohesion, among others. The study aims to investigate whether there is a specific relationship between various qualitative factors of UGS, such as the built environment, natural factors, size and proximity, and PA. Based on the research objectives, research questions for this study has been listed as below:

RQ 1: Which quality factors of UGS are associated with PA? How do they affect PA?

RQ 2: Is there any relationship between demographic characteristics such as gender and age of residents and PA? How do they affect PA?

1.4. Significance and value

As mentioned above, the development of urbanization around the world has shown a rapid and irreversible trend. It is undeniable that in the process of urbanization, the natural environment has been seriously affected. When urbanization wreaks havoc on the natural environment and climate and air quality deterioration poses health risks, the importance of addressing the urbanization-induced health crisis by incorporating green spaces into city planning becomes paramount. However, creating such spaces often necessitates substantial investments from governments and related businesses and ties closely with urban planning. Therefore, there is value in exploring UGS traits that influence people's PA and health. This will provide a theoretical reference for urban UGS designers and relevant policy makers, so that UGS can truly contribute to the promotion of urban residents' health and PA.

Recent years have seen growing attention towards the impact of UGS on PA and health. While various studies have explored the significance of UGS and reached a consensus on its connection with health, most rely on cross-sectional data with a focus on establishing causality. For a thorough exploration of the relationship between the quality of UGS, PA, and health, extensive observation and analysis over a lengthy period is typically necessary for validation.

From a practical standpoint, the implications of these findings are very important. First, for urban planners, understanding the ways in which UGS promotes PA and health levels can help design UGS that is more suitable for the activities of surrounding residents when making relevant decisions. On the other hand, for real estate companies, when designing houses, matching high-quality UGS will be able to more effectively attract consumers to buy. In addition, the results of this study can also provide a theoretical reference for future researchers in this field, enabling them to obtain more advanced research results on this basis.

1.5. Research structure

In the second chapter of this study, the theories and research conclusions of previous researchers related to UGS for health and PA will be presented, which is the basis for the design of subsequent research methods. Next, in the third chapter, the research methods, research design, data collection methods and other contents used in this study are elaborated in detail. In the fourth section, the analysis and research results supporting the conclusions of the fifth section are presented. In the Discussion and Conclusions section of Chapter 5, the research objectives presented in the previous papers are achieved and all research questions are answered.

1.6. Chapter conclusion

All in all, this chapter introduces the background of this research, and thus proposes research objectives and research questions. At the same time, the significance and value of this research are also stated in this chapter. In the last part, this chapter also briefly introduces the structure of the whole study.

2. Literature review

2.1. Chapter introduction

In this chapter, this study extensively reviewed the relevant theories and conclusions proposed by previous studies, and critically explored the relationship between PA and health, the definition and impact of UGS, and the mediating factors of UGS affecting PA, etc. In the section on the mediating factors of UGS affecting PA, this study summarizes previous related studies, and it has been found that the built environment, natural factors, the size of UGS, the distance of UGS from residential areas, infrastructure and sports facilities, and other factors may be mediating factors for UGS to affect PA. In the last part of this chapter, based on the review of previous studies, this study analyzes the gaps in previous studies, and expounds the role of this study in bridging these research gaps.

2.2. PA and health

According to statistics, more than one-third of adults in the world currently lack sufficient PA (Hallal et al., 2012). The detrimental consequences of insufficient PA, including obesity, overweight, chronic diseases, and other health issues, have been widely established (Dishman et al., 2001). Furthermore, it's been demonstrated that a sedentary lifestyle can escalate the risk of premature death and cancer (Westerterp, 2009). Highlighting the importance of this issue, the World Health Organization (WHO) recognizes physical inactivity as the fourth leading risk factor for global mortality (Bauman and Craig, 2005).

It's crucial to acknowledge the numerous health benefits associated with PA—a topic increasingly capturing researchers' attention. Warburton et al. (2006) illustrated that an increase in PA correlates with a lower risk of cardiovascular disease. Similarly, Shaw et al. (2006) found a connection between PA and a decrease in obesity. The impact of PA extends to mental health as well, with studies such as Rethorst et al. (2009) suggesting that enhanced PA can yield positive effects in mitigating depression, anxiety, and stress. Furthermore, PA has been linked to mood enhancement and an overall improvement in well-being (Rethorst et al., 2009; Barton and Prett, 2010).

Delving into the factors influencing PA is essential for encouraging individuals to boost their levels of PA. Utilizing the social ecology theory, Huang and Zhang (2016) suggested five domains—social, environmental, interpersonal, personal, and natural factors—that could potentially impact individual behavior. However, Wang et al. (2019) observed that research generally tends to examine PA from a single perspective. As an example, Schipperijn et al. (2013) focused on the impact of personal factors on PA, while Duncan and Mummery (2005) investigated the

relationship between environmental factors and PA. In subsequent studies, there is also a series of eh that realize that changes in some factors triggered by planning or policies will also have a significant impact on individual PA (Schipperijn et al., 2013).

It can be seen that the role of PA on human health cannot be ignored. Access to green space has been shown to be a decisive factor in promoting PA (Ord et al., 2013). Therefore, next, this article will review the previous studies to explore the various mediating factors that UGS has an impact on PA.

2.3. Definition and impact of UGS

2.3.1. Definition of UGS

Zhang et al. (2022) believed that there is no uniform definition of UGS worldwide. Its definition usually varies with geographical scope or context (Zhang et al., 2022). Generally speaking, UGS includes wetlands, natural woodlands, parks, street green spaces, gardens, etc., which are considered to optimize the quality of human life and the mechanism of the living environment (Van den Berg AE et al., 2010). According to Mao et al. (2020), UGS can increase the contact between people and nature and encourage various physical activities. As mentioned in the research of Wang et al. (2019), UGS can bring people a variety of health benefits and ecosystem services. Especially for women and the elderly, the impact of UGS on their health is more significant (Shen et al., 2022).

2.3.2. The impact of UGS on health

Due to the pressure of city life, people have to endure noise, air pollution, congestion and other problems for a long time. Ofonedu et al. (2013) argued that urban living environments can lead to problems such as depression, irritation and headaches. Although still controversial, there is growing evidence that exposure to nature in urban areas can have positive effects on human health and well-being (Lee and Maheswaran, 2011; Kowarik, 2013). Natural environments in cities have been shown to Extend the life of the elderly population, prevent obesity, and reduce mortality, etc. (Takano et al., 2002).

Furthermore, UGS have shown positive implications for public mental health, including enhancing concentration abilities (Tsunetsugu et al., 2013), facilitating post-disaster recovery (Okvat and Zautra, 2014), and improving self-reported general health (Stigsdotter et al., 2010), among others. In the study of Tyrvainen et al. (2014), it was pointed out that UGS provide people with an environment that can generate creativity, vitality and facilitate recovery. In addition, PA in UGS can also relieve mental fatigue (Golicnik and Thompson, 2010).

As mentioned above, UGS is an open space and a public space for public activities. The effect of UGS on improving health is proved to be impossible to ignore (Ord et al., 2013). In previous studies, researchers often combined objective measurements and Self-report mixed use. For example, in the study of Coombes et al. (2010), it was found that UGS open space has a promoting effect on PA. The World Bank (2011) posits that UGS significantly contribute to the reduction of various chronic diseases. In broader research, there is a consensus that a positive correlation exists between UGS and the frequency of PA (Li et al., 2005; Liu et al., 2017).

Conversely, Potwarka and Kaczynski (2008) negated the assertion that living near parks correlates with healthier body weight in their study.

2.4. Mediating factors of UGS affecting PA

2.4.1. Built environment

Evaluating the impact of UGS on PA, this study highlights the built environment as a critical factor extensively considered by researchers, as corroborated by the review of previous studies. A case in point is a study by Li et al. (2005), which revealed a positive correlation between factors such as household density, the number of street intersections, the presence of green and open recreational spaces, workplace density in the built environment, and pedestrian activities. Further research by Akpinar and Cankurt (2017) delved into the connection between public activity frequency and the features of UGS in Turkey. Their findings suggested that people residing near UGS, with access to sports equipment, picnic spots, and ample tree cover, are likely to engage more frequently in PA. At the same time, the study also found that fireplaces and barbecues lead to a decrease in the duration of PA (Akpinar and Cankurt, 2017).

In the analysis of the built environment of UGS, researchers have consistently paid attention to the influence of the distance between residence and UGS on PA. For example, in Coombes et al. (2010), factors such as the travel time, distance, and transportation convenience from the residence to the green open space are defined as accessibility. This study believes that accessibility is an important factor for UGS to affect PA (Coombes et al., 2010). The above conclusion was also proved in the study of Wang et al. (2019). Taking Nanning, China as the background, this study explores the impact of UGS on residents' public activities. It has been found that since the city has opened two subway lines in recent years, the convenience for citizens to reach UGS has increased significantly, which has further enhanced citizens' participation in local public activities (Wang et al., 2019).

The safety of areas surrounding UGS has also drawn researchers' interest. Schetke et al. (2016) identified safety as a key factor influencing people's use of UGS, while Wang et al. (2019) reported a positive correlation between safety and PA duration. At the same time, the study believes that adding more security patrols around UGS will have a negative impact on PA (Wang et al., 2019). Because more security patrols will cause surrounding residents to think that social unrest, thus Think that staying in UGS for too long will lead to threats to their own safety (Wang et al., 2019).

2.4.2. Natural factors

As a green space, it is necessary to discuss the influence of natural factors in UGS, which often involves attention to the number of trees in UGS, the area of green vegetation, etc. In terms of natural factors, some researchers believe that natural elements such as flowers, trees and grass in UGS, as well as the maintenance and aesthetics of these plants, will have an impact on PA (Akpinar and Cankurt, 2017). Wang et al. (2019) believe that green plants grown in UGS can absorb a large amount of carbon dioxide, carbon monoxide, sulfur dioxide, and some toxic gases exhaled by people. Trees and other green plants can also play a role in filtering and

absorbing dust (Wang et al., 2019). Liu et al. (2017) proposed in their study that green plants in UGS can produce a large amount of dust in the central nervous system Negative ions, which not only affect people's metabolism, but also enhance well-being. However, some researchers believe that too many green plants in UGS will reduce the area available for PA, thus limiting the PA range of residents (Sugiyama et al., 2010).

2.4.3. Scale and distance

This study found in the previous literature that researchers are very interested in the effect of the size of UGS. They explored the impact of scale on the average duration of each PA and the frequency of PA from multiple perspectives. For example, it has been found that attractive and large-scale parks can encourage people to walk more, which is beneficial to health (Cohen et al., 2007). Some researchers also believe that green open spaces in cities are related to PA There is no relationship between them (Schipperijn et al., 2013). Conversely, park size and proximity didn't significantly influence PA according to a study by Hillsdon et al. (2006). Ord et al. (2013) similarly found that the presence of green space in participants' communities did not directly correlate with PA. Wang et al. (2019) discovered that an increase in green area could, paradoxically, decrease residents' activity levels when other variables remained constant. However, this finding conflicts with the conclusion of a study by Kaczynski et al. (2008).

The focus of many researchers has been on the relationship between the size of UGS and the duration and frequency of PA. Sugiyama et al. (2010), for instance, found a positive correlation between UGS size and the length of residents' PA, though the correlation between UGS size and the frequency of PA was negative. Paquet et al. (2013) believed that when the area of UGS is larger, the area of activities per capita is also increased, which encourages residents to stay in UGS for a longer time. After people complete basic sports, they may play chess, dance and other activities, thereby increasing the time of staying.

2.4.4. Infrastructure and sports facilities

It is obvious that for residents, whether adequate sports facilities and infrastructure are installed in UGS may affect the experience of PA. Therefore, infrastructure and sports facilities as intermediary factors have also sparked extensive discussions in previous studies. For example, in the study of Coombes et al. (2010), it was mentioned that there is a positive correlation between better park facilities and green spaces and higher frequency of use, which also means an increase in PA participation. In the study of Kaczynski et al. (2008), it was mentioned that there was a significant correlation between the infrastructure of UGS and the time people took PA, but not the frequency of PA. In the study of Schetke et al. (2016), the above conclusions were further explained. Because when there are complete facilities in the UGS, such as rest booths, convenience stores, toilets, etc., the basic physiological needs of people in UGS can be met. In such cases, it is possible for them to stay longer at UGS for PA (Schetke et al., 2016).

In addition to the infrastructure in UGS, the setup of sports and recreational facilities is also crucial. Wang et al. (2019) found in their research with China as the background that UGS-designed runways, venues for group activities such as "square

dancing" and "tai chi", are popular with Chinese residents. At the same time, the study found that UGS with a basketball court significantly increased people's PA time. The study further found that facilities such as volleyball courts, skating rinks, and table tennis tables can significantly increase the frequency of people going to UGS for PA (Wang et al., 2019). However, in the study of Schipperijn et al. (2013), it was found that Roller skating venues may reduce the PA frequency of surrounding residents. Because the roller skating venue covers a large area, roller skating can easily cause injuries to participants and even people nearby. Therefore, when a roller skating field is set up in UGS, the frequency of PA will be hindered to a certain extent.

2.4.5. Other influencing factors

In addition to the built environment, natural factors, scale and other factors of UGS, this study also found that gender, age and interpersonal relationship were used as mediating factors in previous studies to explore the impact of UGS on PA. Among them, the researchers relatively unanimously believe that men have less PA time than women. For example, in the study of Evenson et al. (2016), it was mentioned that in terms of the duration of PA, women are usually higher than men, which also reflects that women have longer leisure time than men. Kaczynski et al. (2008) also made a similar point. It indicated that women prefer to spend longer time in the adjacent UGS for public activities (Kaczynski et al., 2008). The study also pointed out that because men Often bear the main responsibility for obtaining financial resources in the family, so they have less time available for PA than women (Kaczynski et al., 2008).

Income and age are also mediators of UGS' impact on PA. According to Jun et al. (2017), residents with higher income tend to spend longer time in UGS for leisure activities. Wang et al. (2019) found in their study that when other factors were kept constant, the frequency of PA in UGS would increase with age. However, Evenson et al. (2016) came to the opposite conclusion in their study. It was claimed that fewer older adults were observed in city parks.

In addition, interpersonal factors are also considered to be mediating factors for UGS to affect PA. It has been found that when PA is performed at UGS with colleagues or other organizations, people also participate in PA longer (Wang et al., 2019). According to the study, this means that colleagues and organizations are supporting individuals to conduct PA's core source of social support. At the same time, similar conclusions were obtained in the study of Schetke et al. (2016). Schetke et al. (2016) mentioned in their research that tourists in UGS prefer to do PA with friends or family. However, some researchers have questioned the above point of view. In the research of Hillsdon et al. (2006), it is pointed out that compared with group activities, the time of individual travel is more flexible, which will help to increase the frequency of people doing PA in UGS.

It can be seen that there are various intermediary factors in the influence of UGS on PA. In current studies, researchers usually only focus on positive associations, and few researchers report negative or nonexistent associations. Although the impact of different characteristics of UGS on PA is still controversial,

in many cities around the world, there is still general agreement that increasing UGS can promote PA.

2.5. Research gaps

Based on a comprehensive examination of prior research, the current study reveals that scholars have generally arrived at a consensus regarding the association between uUGS and the health of populations. Nonetheless, there remains a significant divergence of opinions regarding the intermediary elements contributing to this correlation. Insufficient management of variables impacting outcomes during selection study sites and an excessively random approach to sample selection exhibited a slight bias when faced with the intricate nature of influencing factors. In terms of survey methods, previous studies generally used questionnaires and interviews to obtain data. Participants were asked to evaluate their own fitness level and report other subjective feelings. Such a survey method may produce bias in the research results due to problems such as participants' memory bias (Dallimer et al., 2014).

In light of the limitations observed in prior research, this study aims to address these gaps by employing a causal experimental design that emphasises the control of confounding variables, drawing from previous causal experiments and cross-sectional studies. Specifically, the study will categorise participants into subgroups, enabling cross-sectional comparisons among these distinct groups. The research will examine variations at the municipal, communal, and individual levels and assess the well-being of the participants by directly observing their PA levels on-site. This approach minimises any potential subjective bias in the data collection process. In addition, this study will further explore the specific relationship between UGS and PA and other health behaviors.

2.6. Chapter conclusion

In summary, this chapter critically reviews previous researchers' conclusions on the relationship between UGS and PA. The theories of previous studies not only provide reference and basis for the research design of this study, but also enable this study to discover the gaps in the previous research, so that it can better choose the research direction to fill the research gap. In the next chapter, the research methodology of this study will be elaborated (**Table 1**).

Table 1. Summary of factors affecting PA in previous studies.

No.	Authors & Years	Influencing factors	How do these factors affect PA?
1	Hillsdon et al. (2006)	Interpersonal factors	Compared with group activities, the time of individual travel is more flexible, which will help to increase the frequency of people doing PA in UGS.
2	Schetke et al. (2016)	Interpersonal factors	Tourists in UGS prefer to do PA with friends or family.
3	Evenson et al. (2016)	Age	It was claimed that fewer older adults were observed in city parks.
4	Wang et al. (2019)	Age	PA frequency in UGS increased with age when other factors were controlled for.
5	Kaczynski et al. (2008)	Gender	Women prefer to spend longer in public activities in adjacent urban green spaces.

Table 1. (*Continued*).

No.	Authors & Years	Influencing factors	How do these factors affect PA?
6	Evenson et al. (2016)	Gender	In terms of the duration of PA, women are usually higher than men, which also reflects that women have longer leisure time than men.
7	Shen et al. (2022)	Gender, Age	The health effects of UGS are more pronounced in women and the elderly.
8	Li et al. (2005)	Household density, Number of street intersections, Green and open recreational spaces, Workplace density	There was a positive correlation between these factors and walking activity.
9	Akpinar & Cankurt (2017)	Distance to living areas, Sports equipment, Picnic areas, Planted trees, Fireplace and BBQ.	The frequency of PA will increase when people live closer to urban green space, install available sports equipment, set up picnic areas, and plant more trees. Fireplaces and barbecues will lead to the duration of PA decrease.
10	Coombes et al. (2010)	Accessibility	In Coombes et al. (2010), factors such as the travel time, distance, and transportation convenience from the residence to the green open space are defined as accessibility. Accessibility is an important factor for UGS to affect PA.
11	Wang et al. (2019)	Safety, Green plants.	There is a positive correlation between safety and the duration of PA. Green plants can absorb a large amount of carbon dioxide, carbon monoxide, sulfur dioxide, and some toxic gases exhaled by people. Trees and other greenery can also filter and absorb dust.
12	Sugiyama et al. (2010)	Green plants	Excessive greenery in UGS reduces the area available for PA, thereby limiting PA coverage for residents.
13	Cohen et al. (2007)	Scale of UGS	Attractive and large parks can have health benefits by encouraging more walking.
14	Schipperijn et al. (2013)	Scale of UGS	No relationship between green open spaces in cities and PA.
15	Kaczynski et al. (2008)	Scale of UGS	The total area of urban green open space was significantly correlated with PA.
16	Sugiyama et al. (2010)	Scale of UGS	There was a positive correlation between the size of UGS and the duration of residents' PA, but a significant negative correlation with the frequency of PA.
17	Coombes et al. (2010)	Park infrastructure	There is a positive correlation between better park facilities and green spaces and higher frequency of use, which also means higher PA participation.
18	Kaczynski et al. (2008)	Park infrastructure	There was a significant correlation between the infrastructure of UGS and the time people took PA, but not the frequency of PA.
19	Schetke et al. (2016)	Park infrastructure	When there are complete facilities in the urban green space, such as rest booths, convenience stores, toilets, etc., the basic physiological needs of people in UGS can be met. In such cases, it is possible for them to stay longer at UGS for PA.
20	Wang et al. (2019)	Park infrastructure	UGS with a basketball court can significantly increase people's PA time. Skating rinks, table tennis tables and other facilities can significantly increase the frequency of people going to UGS for PA.
21	Schipperijn et al. (2013)	Park infrastructure	Roller skating venues may reduce the PA frequency of surrounding residents. Because the roller skating venue covers a large area, roller skating can easily cause injuries to participants and even people nearby.
Factors focused on in this study	Built environment, natural factors, size and distance, infrastructure, sex, age of inhabitants.		

3. Methodology

3.1. Chapter introduction

In academic research, methodology provides the bridge linking research questions to conclusions. Therefore, this chapter will elaborate the specific research methods in detail, emphasising that, to improve the reliability and validity of the research, the research methods adopted improve the credibility of the research results and help subsequent researchers understand the ideas of this study (Sileyew, 2019). This chapter will focus on various aspects of the research methodology, including the overall research method, research design, measures and procedures, data analysis, and so on.

First, this chapter will introduce the study design, including the methodology and its rationale and advantages, the variables on which this study focuses, the structure of the study, and the interaction between variables. Research design provides guidance for data collection and analysis and is also a guarantee for the ultimate realisation of research goals (Wright et al., 2016). The chapter will then describe the methods and procedures of data collection, including selection criteria, strengths, limitations, and fit within this study. In addition, the sampling techniques, tools, instruments, and related procedures used for data collection will be introduced. A thorough overview of the data collection process ensures the reliability of the data used for the study (Axinn and Pearce, 2006).

After data collection is complete, systematic data analysis can turn raw data into valuable insights. Techniques and strategies for processing and interpreting collected data will also be introduced in this chapter, covering data collation, specific statistical methods, and so on. The detailed elaboration of the data analysis process ensures the objectivity of the research conclusions.

It is also crucial to address research ethics, as researchers have a responsibility to ensure the wellbeing and integrity of participants (Bergdahl et al., 2020). Participants' informed consent, protection of data privacy, and other ethical considerations will be introduced in detail in this chapter. This not only ensures the protection of research participants, but also provides support for the credibility and integrity of the research (Bergdahl et al., 2020).

Finally, the chapter concludes with a summary to help readers best understand the nature, and further emphasise the integrity and rigor, of the research method.

3.2. Research method

This study aimed to explore the association between UGS quality, PA and health, focusing on the long-term effects of UGS while controlling for a variety of environmental factors. According to the fourth layer of the research onion model proposed by Saunders et al. (2009), researchers must decide whether to use a single method or a combination of methods in a study. Further, researchers ultimately decide on the research institute by the type of data they want to collect Whether qualitative or quantitative methods are used. In addition, researchers can combine qualitative and quantitative methods to form mixed methods.

In this study, qualitative and quantitative research were used in combination. The researchers used the MOHAWk observation tool (Benton et al., 2020) to record the behaviour and characteristics of individuals who visited UGS during the observation period. The collected quantitative data were statistically analysed to explore correlations between UGS quality, PA, and fitness levels. The central purpose of quantitative research is to discover important issues through numerical analysis of research objects (Heale and Twycross, 2015). Through the statistical analysis of quantitative research, people's understanding of a variety of social phenomena is promoted (Heale and Twycross, 2015). Therefore, quantitative research is suitable for the analysis of the above variables.

Prior to data collection, the researchers conducted a qualitative assessment of the data collection sites to identify problems such as litter, noise, and broken glass. Uncivilised behaviour and situations in these UGSs were identified as environmental factors to help explain the research objectives. Bryman (2006) pointed out that the process of collecting data through field observation in the natural environment, summarising rational concepts, in-depth investigation of social phenomena, etc. to explain things is defined as experience or interview. Therefore, qualitative methods are applicable to the researchers' environmental quality assessment of the sites.

To assess the quality of the UGS environment, this study used the MOHAWk and Environmental Assessment of Public Recreational Spaces (EARPS) Mini observation tools, which have previously been shown to be feasible (Geremia et al., 2019). Evaluations are based on incivility assessments and demographic data collection. This means that mixed research methods are effective in achieving the research purpose of this study, providing a more comprehensive basis for answering research questions. As mentioned in Creswell and Creswell (2005), when a single research method cannot obtain satisfactory results, it is generally preferable to combine multiple research methods. The combination of qualitative and quantitative analysis is very common in previous studies: according to Sandelowski (2000), qualitative and quantitative are programmatically compatible, and qualitative and quantitative data co-existing do not intersect. Therefore, for this study, the use of mixed methods can maximise the practicability of the research objectives.

Positivist research philosophy, obtaining information and drawing research conclusions through observation and experimentation (Park et al., 2020), was also used in this study. Among them, observation and measurement are the core of empirical research (Park et al., 2020). This study adopts experimental data obtained from observations at four sites in Edinburgh, Scotland. Therefore, this is a study based on positivism.

3.3. Research design

The data were collected in Edinburgh, Scotland. Edinburgh has a population of approximately 520,000 and encompasses a land area of 264 square kilometres, with a population density of 1994 inhabitants per square kilometre. The following percentages represent the distribution of individuals across different age groups: 0 to 17 years old, 16.6%; 17 to 44 years old, 44.8%; 45 to 64 years old, 23%; and 65 years or older, 15.4% (National Records of Scotland, 2013). According to the same

source, the demographic composition of the residents indicates that the majority are classified as white (91.7%), while the remaining 8.3% are identified as belonging to ethnic-cultural minorities, primarily Asian, Mixed or multiple ethnic groups, and African.

The study randomly selected UGS from quadrants classified based on size (large or small) and socioeconomic status (SES) (high or low) (**Table 2**). The quadrants were as follows: large areas with high SES, large areas with low SES, small areas with high SES, and small areas with low SES. Data regarding the size of the UGS areas and SES were acquired through an evaluation conducted by the City of Edinburgh Council (https://www.edinburgh.gov.uk/downloads/file/24775/the-value-of-the-council-s-parks) and further supplemented by utilising Google Maps and DigiMap data, employing the SES classification standard (https://simd.scot/#/simd2020/BTTTFTT/14/-3.1777/55.9565/). This assessment ranks the level of multiple deprivation in various areas of Edinburgh. The assessment utilises the SES classification standard, which encompasses rankings in the domains of income, employment, education/skills, and housing. Schipperijn et al. (2013) demonstrated a positive correlation between the size of UGS and PA levels. Similarly, Kaczynski et al. (2014) posited that larger park areas offer residents a better range of PA. Previous research has demonstrated that SES significantly affects an individual's body mass index (BMI) (Rundle et al., 2008).

A total of 144 city parks in Edinburgh were ranked based on the number of extrapolated visitors, divided into two groups: 69,000 visitors (63 parks) and 138,000 visitors (14 parks). The parks were then further categorised based on their size, with 41 parks ranging from 1–5 hectares (69,000 visitors) and 7 parks ranging from 6–10 hectares (138,000 visitors). Finally, the top 30% of parks based on socioeconomic status (SES) were selected, as well as the bottom 30%. Four parks were randomly selected from all UGS across quadrants (there is only one large UGS located in a high SES and eligible for screening), with particular attention paid to keeping the number of extrapolated visitors consistent for large/small area parks to control for variability in the data (Beta.edinburgh.gov.uk). There exist two parks of large area that consistently attract a similar number of visitors yet differ in terms of their SES. Similarly, two smaller parks consistently attract a comparable number of visitors but also exhibit contrasting SES. The corresponding factors were controlled on the cross-sectional comparisons to obtain more precise results.

Table 2. Summary of extracted UGS data.

UGS	Area (ha)	Socioeconomic status	Extrapolated visitors
Harrison Park	7.81	High	138,000
Pilrig Park	6.88	Low	138,000
Orchard Park	2.49	High	69,000
Granton Crescent Park	1.72	Low	69,000

Harrison Park and Pilrig Park possess dimensions that exceed the capacity of a single observer to ensure comprehensive coverage of the entire designated observation area (**Figure 1**). To ensure uniformity in the size of observation areas and enhance the reliability of collected data, a parcel of land measuring

approximately two hectares at these locations was allocated for observation purposes, containing large green areas and movable spaces. It is also attached to the main road of the park's peers, which ensured that the number of participants at the time of observation had a high confidence level for the whole park (**Figure 2**). Importantly, these areas were comparable to the observation areas at Orchard Park and Granton Crescent Park. The choice of observation points was based on facing large green areas with movable spaces and minimising the impact of sheltered objects such as trees and facilities within the park.

Figure 1. Observation areas and observation points in the four parks.

Figure 2. Site photographs of observation points in the four parks.

The study employed the MOHAWk Tool to observe park users' characteristics and engagement in PA. The data were collected from July to August 2023, with a mean temperature of 15 ℃. Four students from the University of Edinburgh were recruited as observers through the Wechat Social App, without compensation. All four had previous experience using other observation tools; before collecting data, they underwent training on EARPS Mini and MOHAWk. Each of the observers observed one park simultaneously to ensure temporal data collection consistency.

3.4. Measures and procedures

3.4.1. MOHAWk

MOHAWk is designed for conducting field observations to document various categories of PA in UGS, including sedentary behaviour, walking, strenuous exercise, social interaction, and attention to the environment. Data are typically documented using a writing instrument, such as a pen, on a physical medium, such as paper. Edinburgh experiences a significant number of rainy days during the summer months, posing challenges to the observation and data collection process. In contrast to alternative observation tools, the MOHAWk tool does not suspend observations during inclement weather unless the duration of precipitation exceeds 50% of the total observation period. The MOHAWk tool incorporates an evaluation of uncivilised behaviour at the site in addition to documenting crowd data, thereby offering a valuable advantage in facilitating direct comparisons of the site's environment. Observers record the date/day, site name, observer's initials, start time, and end time at the top of the observation form. Before the start of the observation, observers were told to conduct a qualitative evaluation of the green space and to collect data on the presence of incivilities in the green space (including general litter, broken glass, and noise).

For all individuals entering the target area, observers used the MOHAWk tool to record gender, ethnicity, age group, level of PA, whether visitors were engaged in social interactions or paying attention to their surroundings, type of activity, and whether they required mobile assistance. At the conclusion of the observation period, observers documented headcounts on the MOHAWk summary sheet and recorded the duration of any precipitation.

Observers continuously scanned their target area for one hour. The observer should record a person's gender (male or female), race (white or non-white), age group (infant, child, adolescent, adult), level of PA (sedentary, walking, strenuous), social interactions (connectivity), attention to the environment (noticing), type of activity (bicycling, using a phone, walking the dog, or other predetermined activity), and whether mobility assistance was required (yes or no). Record all individuals entering the target area, excluding those in vehicles (e.g., cars, motorcycles). If the individual being observed returns to the target area during the initial observation period, it is unnecessary to create a second recording. Observations were conducted over a two-week span from July to August 2023, with one weekday and one rest day selected for data collection per site per week. The times for observations were 9:00–10:00 a.m., 1:00–2:00 p.m., and 5:00–6:00 p.m. Data were collected over four days

in each park, resulting in 12 hours of data collection; whenever feasible, observations were conducted on sunny days.

3.4.2. EARPS Mini

The EARPS Mini is a comprehensive observational tool used to evaluate various characteristics of the park, encompassing 28 assessments focusing on the park environment and its associated facilities. Geremia et al. (2019) provided evidence for the efficacy of using EARPS Mini for assessing the quality of green spaces through coding. The EARPS Mini observation tool was utilised before the commencement of the observation, and no substantial modifications were made to the UGS throughout the observation period, thus necessitating only a single assessment. The evaluations of the park environment covered elements such as paved and unpaved trails, open spaces, a swimming pool, a beach, a sidewalk, a skating area, a path, a meadow, a wooded area, a pond or lake, streams or creeks, a fountain, views beyond the park, a designated wildlife area, and so on.

The assessment of park amenities encompassed various components such as playsets or structures, athletic fields, indoor recreation centres, grills or fire pits, picnic areas, restrooms, shelters, pavilions, and gazebos. The establishment encompasses an entertainment venue/stage, a designated parking area, a navigation map, and patrons' seating arrangements.

3.5. Data analysis

The study evaluated the quality of four UGS environments (EARPS Mini) in terms of both the assessment of incivilities (MOHAWk) and the collection of population data (MOHAWk). Controlling for environmental factors, the effects of green space quality (including assessment of incivilities) on PA (various types) and health (moderate to vigorous PA) were investigated to expand the application of related experiments in related studies.

The primary tool employed for data analysis was SPSS. Initially, the researchers conducted UGS quality assessment (EARPS Mini) and assessment of uncivilised behaviour (MOHAWk) for all four parks to discern the variations in heterogeneity across the different parks. The variables were subjected to descriptive analysis, which involved the calculation of counting statistics, percentages, and other relevant measures. Subsequently, correlation analysis was conducted to examine the relationships among the variables. Additionally, analysis of variance, including chi-square tests, was performed to assess the association between PA levels and factors such as age, gender, and ethnicity, to facilitate the exploration of potential links between green space quality and PA and health outcomes.

3.6. Research ethics

This study was approved by the Ethics Committee of the Faculty of Arts, University of Edinburgh.

The data obtained from the site and population in this study will be utilised exclusively for academic research and will not be employed for any alternative objectives.

The observation process was carefully designed to mitigate potential discomfort and safeguard the participants' privacy; for instance, by avoiding prolonged observation of any one individual.

Participants were entitled to provide informed consent for participating in the observation, and observers were permitted to wear vividly coloured attire and exhibit placards to notify participants.

Participants were not exposed to any risks, and the confidentiality of the collected data will be maintained, ensuring non-disclosure.

3.7. Chapter conclusion

This chapter has provided an overview of the methodology employed in this study, encompassing the research design, data collection measures and procedures, data analysis methods, and adherence to research ethics guidelines. The temporal aspects of the observations exhibit certain limitations, which necessitate consideration in future studies. By doing so, researchers can expand the range of available remedial actions in adverse weather conditions or unforeseen circumstances. In the next chapter, the results of the data collection and analysis will be elaborated.

4. Results

4.1. Chapter introduction

In this chapter, the data collected will be collated to analyse the specific impacts of the assessment of UGS (EARPS Mini) and the assessment of uncivilised behaviour (MOHAWk) on the crowds and PA in the four parks and to make a side-by-side comparison of the differences between them. The number and percentage of people of different ages, genders, and races participating in PA were obtained by summarizing the statistics of the four parks. Correlation analyses were conducted using chi-square tests for the effects of relevant variables on activity types, the effects of relevant variables on PA level, and the effects of related variables on status to explore the relationship between UGS quality and PA. Relationship between UGS quality and PA.

4.2. Overview of facilities in each park

A comprehensive dataset comprising 1,401 observations was gathered from the four parks, and an overview of the data collection process is presented in **Table 3**. The number of individuals recorded in Harrison Park and Pilrig Park exceeded that of Orchard Park and Granton Crescent Park. Notably, more women (858) participated in UGS than men (543). Most of the population consisted of adults (948), primarily of white ethnicity. Dog walking was the most popular activity type. Overall, activity levels tend to favour walking, with taking notice about equal to connect.

Table 3. Characteristics of the population and PA (N = 1401).

Name		**Harrison Park**	**Pilrig Park**	**Orchard Park**	**Granton Crescent Park**
Total		527	401	260	213
Gender	Female	335	194	175	154
	Male	192	207	85	59
Generation	Infant	23	21	5	7
	Child	53	47	20	54
	Teen	48	18	10	14
	Adult	356	263	210	119
	Older Adult	45	49	13	20
Race	White	487	274	247	199
	Non-White	40	102	13	14
Activity Type(s)	Cycling	0	62	0	0
	Using phone	14	29	7	7
	Dog walking	71	77	56	19
Activity Level(s) Activity Status	S (sedentary)	61	89	26	17
	W (walking)	392	195	199	152
	V (vigorous)	74	81	37	42
	TN (tack notice)	389	103	159	59
	C (connect)	329	123	103	91

From the **Table 4** above, the park's representation in terms of environment and amenities is enhanced as the total score increases. However, it is essential to consider specific factors when making comparisons. Harrison Park and Pilrig Park have the highest total scores of 13, followed by Granton Crescent Park with 12 and Orchard Park with a score of 9, which is a significant deviation from the other three. In terms of site conditions and location, combined with **Table 5**, Harrison Park is large and frequented mainly by the rich, with plenty of amenities and little to no ordinary trash but more graffiti; Pilrig Park also scored 13, although it does not have the scenery of Harrison Park, it does offer a grill/fire pit and a picnic area, from the site Pilrig Park, is more dated, has many people of colour and is the only one of the four parks with direct access for bikes. It appears to have much general litter and has evidence of alcohol and drug use. Orchard Park scored the lowest but has all the amenities of a standard park, and unlike the other three, does not offer play facilities, which is also consistent with the high number of dogs observed on site, with little uncivilised behaviour apart from dog mess which could be observed. On the other hand, Granton Crescent Park is close to the seafront, has a high number of children and is slightly cleaner, although it is also a low socioeconomic status area. Very little alcohol and broken glass were present.

Table 4. EAPRS Mini statistical table.

Presence of the below in the park	Harrison Park	Pilrig Park	Orchard Park	Granton Crescent Park
1. Paved trail	1	1	1	1
2. Unpaved trail	0	1	0	0
3. Open space	1	1	1	1
4. Swimming pool	0	0	0	0
5. Beach	0	0	0	0
6. Sidewalk (adjacent to the park)	1	1	1	1
7. Playset or structure	1	1	0	1
8. Other play equipment	1	1	0	1
9. Athletic field	1	0	0	0
10. Athletic court	0	0	0	0
11. Indoor recreation center	0	0	0	0
12. Skate area	0	0	0	0
13. Path	1	1	1	1
14. Meadow	1	1	1	1
15. Wooded area	1	1	1	1
16. Pond/lake	0	0	0	0
17. Streams/creeks	0	0	0	0
18. Fountain	0	0	0	0
19. Grill/fire pit	0	1	0	0
20. Picnic area	0	1	0	0
21. Restroom	0	0	0	0
22. Shelter/pavilion/gazebo	0	0	0	0
23. Entertainment venue/stage	0	0	0	0
24. Views outside park	1	0	1	1
25. Wildlife area	1	0	0	0
26. Parking lot	0	0	0	1
27. Map	1	1	1	1
28. Any seating	1	1	1	1
TOTAL	13	13	9	12

Table 5. Statistical table of uncivilized behaviors.

	General litter	Evidence of alcohol use	Evidence of drug taking	Graffiti	Broken Glass	Vandalism	Dog mess	Noise
Harrison Park	5	4	4	12	5	8	8	6
Pilrig Park	12	10	9	4	9	8	8	4
Orchard Park	4	5	4	4	5	4	9	4
Granton Crescent Park	6	5	4	4	8	4	4	4

These four parks are used as examples of different types of parks; Harrison Park represents a high socioeconomic status area, large park; Pilrig Park represents a low socioeconomic status area, large park; Orchard Park represents a high socioeconomic status area, a small park; and Granton Crescent Park, a small park in the low socioeconomic status zone. For these four typical parks, the MOHAWK observation method assessed three levels of PA and two health behaviours in urban spaces.

4.3. Statistics of each park

From **Table 6** we found that Harrison Park's data for weekday hours shows that females are the leading group of people coming to the park for activities in most age groups, with the most significant number of people coming to play being females among adults. In terms of the overall population, dog walking is 12.75% of the population, while the rest are using phones. The highest percentage of activity status is also in walking state, at 69.54%, with slightly more people in vigorous state than in sedentary state. Harrison Park's data for the weekend hours shows a 17% increase in the number of people visiting the park compared to the weekdays. Regarding the population, 13.33% were dog walking, while the remainder used phones. The highest percentage of activity status was also walking state at 77.54%. The population in vigorous state was comparable to that in sedentary state.

Table 6. Harrison Park—Weekday (Weekend) statistical table.

Harrison Park Weekday (Weekend)		**Cycling**	**Using phone**	**Dog walking**	**S**	**W**	**V**	**TN**	**C**
Infant	female	0 (0)	0 (0)	0 (0)	5 (11)	0 (0)	0 (0)	1 (8)	0 (5)
	male	0 (0)	0 (0)	0 (0)	1 (6)	0 (0)	0 (0)	0 (4)	0 (4)
Child	female	0 (0)	0 (0)	0 (0)	2 (1)	3 (13)	7 (8)	4 (15)	11 (19)
	male	0 (0)	0 (0)	0 (0)	0 (2)	4 (6)	3 (4)	3 (10)	7 (10)
Teen	female	0 (0)	0 (0)	1 (4)	0 (0)	1 (7)	2 (1)	1 (5)	2 (6)
	male	0 (0)	0 (1)	0 (1)	0 (0)	3 (7)	20 (7)	0 (7)	20 (10)
Adult	female	0 (0)	3 (3)	18 (20)	11 (2)	100 (119)	6 (5)	100 (106)	54 (84)
	male	0 (0)	2 (5)	8 (8)	6 (6)	39 (52)	5 (5)	37 (48)	23 (42)
Older Adult	female	0 (0)	0 (0)	3 (1)	1 (1)	14 (13)	0 (0)	12 (12)	12 (8)
	male	0 (0)	0 (0)	1 (4)	2 (4)	5 (4)	0 (0)	7 (7)	6 (5)
Total		0 (0)	2.05% (3.15%)	12.75% (13.33%)	11.52% (11.57%)	69.54% (77.54%)	17.69% (10.52%)	67.9% (77.89%)	55.55% (67.71%)

The Infant group saw more socialising and take notice states on weekends than weekdays. In the teen group, almost everyone was at a PA level of vigorous on weekdays and in social behaviour. Far more men than women were active in the park. On weekends women are more likely to be in the walking state, while men are each half in the walking and vigorous states. Almost all would be in connect and take notice behaviours, with slightly more males than females active in the park. In the adult group, more people chose walking on weekdays, 39 males and 100 females. The majority were in the take notice behaviour of the activity. At weekends 52 males

and 119 females chose walking. There was an increase in those in connect state. The older adult group was at a steady state in terms of the number of people in various activities on weekdays versus weekends.

From **Table 7** we found that the data for Pilrig Park during weekday hours shows that females are the main demographic coming to the park for activities in most age groups, with the most significant number of people coming to play being females among adults. Looking at the overall population, dog walking 24.86% of the population, using a phone 10.49%, and cycling 9.94%. The highest proportion of activity status is also walking state, accounting for 65.19%. In contrast, the proportion of people in vigorous state is lower than that of sedentary state, and those in take notice and connect status are comparable. The data of Pilrig Park during the weekend time shows that the number of males coming to play is comparable to that of females in most age groups, and it varies in different age groups. Regarding the overall crowd, dog walking had 14.67% of the crowd, using phones had 4.58%, and cycling had 20.18% of the crowd. The highest proportion of activity status is also walking state, accounting for 36.23%, but the number of people in sedentary state and vigorous state also accounts for nearly 25%, and the people in connect status are higher than those in take notice status.

Table 7. Pilrig Park—Weekday (Weekend) statistical table.

Pilrig Park Weekday (Weekend)		**Cycling**	**Using phone**	**Dog walking**	**S**	**W**	**V**	**TN**	**C**
Infant	female	0 (0)	0 (1)	0 (0)	6 (5)	4 (0)	0 (0)	4 (0)	5 (0)
	male	1 (0)	0 (0)	0 (0)	3 (1)	3 (0)	1 (0)	2 (0)	2 (0)
Child	female	0 (1)	0 (0)	1 (0)	0 (4)	4 (0)	3 (9)	5 (1)	7 (1)
	male	1 (2)	0 (0)	0 (1)	0 (0)	8 (8)	4 (7)	5 (2)	5 (1)
Teen	female	0 (0)	0 (0)	0 (0)	1 (3)	0 (2)	0 (0)	0 (1)	0 (2)
	male	0 (4)	0 (0)	0 (0)	0 (4)	0 (4)	0 (4)	0 (2)	0 (3)
Adult	female	1 (19)	8 (3)	15 (11)	18 (11)	41 (24)	1 (19)	20 (10)	23 (18)
	male	12 (18)	9 (5)	16 (16)	8 (20)	35 (25)	12 (18)	15 (20)	14 (30)
Older Adult	female	1 (0)	0 (0)	7 (4)	1 (2)	11 (10)	1 (0)	9 (0)	7 (3)
	male	2 (0)	2 (1)	6 (0)	1 (1)	12 (6)	2 (0)	6 (1)	3 (1)
Total		9.94% (20.18%)	10.49% (4.58%)	24.86% (14.67%)	20.99% (23.39%)	65.19% (36.23%)	13.25% (26.14%)	36.46% (16.97%)	36.46% (27.06%)

Age groups showed significant differences in activity and social behaviour between weekdays and weekends. The Infant group had multiple activity states on weekdays, and predominantly sedentary state with cases of using phones on weekends. The child group was socially active on weekdays and had no sedentary state, while on weekends, they were less socialised and had sedentary state. The teen group had only one female in sedentary state on weekdays and more balanced weekend activity levels. The adult group had a similar pattern of activity on both days but was more numerous on weekdays. The older adult group was

predominantly walking state on weekdays and weekends but had less social behaviour on weekends.

From the **Table 8** above, Orchard Park's data during weekday hours shows that females tend to be the main demographic coming to the park for activity in most age groups, with the most significant number of people coming to play being females among adults. Regarding the overall population, 21.42% is dog walking, while the remainder is using phone. The highest percentage of activity status is also walking state, at 73.21%, with a comparable number of people at PA levels vigorous and sedentary. Data from Orchard Park during the weekend shows that in most age groups, the number of females visiting the park is higher than the number of males. Higher than males. Regarding the overall population, 20.994% were dog walking, and 2.02% were using phones. The highest proportion of activity status is walking state, accounting for 77.7%, and the number of people in sedentary and vigorous state is smaller, and the number of people in connect status is lower than that in take notice status.

Table 8. Orchard Park—weekday (weekend) statistical table.

Orchard Park Weekday (Weekend)		**Cycling**	**Using phone**	**Dog walking**	**S**	**W**	**V**	**TN**	**C**
Infant	female	0 (0)	0 (0)	0 (0)	3 (2)	0 (0)	0 (0)	0 (0)	0 (0)
	male	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Child	female	0 (0)	0 (0)	0 (0)	0 (0)	0 (1)	3 (5)	0 (1)	3 (6)
	male	0 (0)	0 (0)	0 (0)	0 (0)	1 (3)	2 (5)	0 (1)	3 (8)
Teen	female	0 (0)	1 (0)	2 (4)	0 (0)	3 (5)	0 (0)	2 (5)	1 (1)
	male	0 (0)	0 (0)	0 (0)	0 (0)	0 (2)	0 (0)	0 (2)	0 (2)
Adult	female	0 (0)	1 (1)	17 (21)	5 (4)	52 (75)	3 (8)	42 (59)	21 (24)
	male	0 (0)	2 (2)	3 (6)	5 (6)	18 (26)	7 (4)	14 (20)	14 (14)
Older Adult	female	0 (0)	0 (0)	1 (0)	0 (1)	5 (1)	0 (0)	5 (2)	2 (0)
	male	0 (0)	0 (0)	1 (0)	0 (0)	3 (2)	0 (0)	3 (2)	2 (1)
Total		0 (0)	3.57% (2.02%)	21.42% (20.94%)	11.6% (8.78%)	73.21% (77.7%)	13.39% (14.86%)	58.92% (62.16%)	41.07% (37.83%)

The differences between weekdays and weekends were mainly in: the infant group had slightly more cases on weekdays; in the child group, there were more females than males on weekdays, and the opposite was true on weekends; the teen group had diminished vigour on both days, and was predominantly in the walking state; in the adult segment, more males were choosing the vigorous state on weekdays, and more females on weekends and more females in the take notice state on weekdays; in the older adult group, there were all females in the walking state and a small amount of sedentary state and social behaviour on weekends.

From **Table 9** we found that the data for Granton Crescent Park during weekday hours shows a difference between males and females coming to the main activity in different age groups. Regarding the overall population, 7.69 per cent of people were dog walking, and 1.78 per cent were using phones. The highest

proportion of activity status is also walking status, accounting for 68.13%. In contrast, the proportion of people in vigorous status is higher than that of sedentary status, and the proportion of people in take notice status is lower than that of connect status. The data of Granton Crescent Park during the weekend shows that the number of female visitors is higher than that of males in most age groups. Regarding the overall crowd, there were 10.71% of the dog walking crowd and 1.78% of the using phone crowd. The highest percentage of activity status is also walking state, with 79.46%. Those with vigorous levels are higher than sedentary levels, and those with connect status are slightly higher than those with take notice status.

Table 9. Granton crescent park—weekday (weekend) statistical table.

Granton Crescent Park Weekday (Weekend)		**Cycling**	**Using phone**	**Dog walking**	**S**	**W**	**V**	**TN**	**C**
Infant	female	0 (0)	0 (0)	0 (0)	3 (4)	0 (0)	0 (0)	0 (0)	0 (0)
	male	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Child	female	0 (0)	0 (0)	0 (0)	0 (0)	4 (11)	7 (7)	0 (1)	8 (12)
	male	0 (0)	0 (0)	0 (0)	1 (0)	1 (5)	10 (7)	0 (1)	11 (12)
Teen	female	0 (0)	0 (0)	0 (0)	0 (0)	2 (4)	0 (0)	0 (0)	2 (4)
	male	0 (0)	0 (0)	0 (1)	0 (0)	2 (6)	0 (0)	0 (1)	2 (6)
Adult	female	0 (0)	4 (1)	7 (10)	1 (0)	43 (50)	1 (9)	18 (21)	12 (8)
	male	0 (0)	1 (1)	0 (0)	0 (1)	6 (4)	2 (1)	1 (0)	6 (1)
Older Adult	female	0 (0)	0 (0)	0 (0)	1 (2)	2 (4)	0 (0)	2 (5)	1 (3)
	male	0 (0)	0 (0)	0 (1)	1 (3)	2 (5)	0 (0)	3 (6)	1 (4)
Total		0（0）	5.49% (1.78%)	7.69% (10.71%)	7.69% (8.92%)	68.13% (79.46%)	21.97% (21.42%)	26.37% (31.25%)	47.25% (44.64%)

Between weekdays and weekends, the age groups show different patterns of activity and socialisation. The infant group has three cases of sedentary state on weekdays and four on weekends. The child group has slightly fewer females than males and only one case of sedentary state on weekdays, but the weekends are similar. The teen group has both males and females favouring the walking status on weekdays, and both are in connect socialisation, while on weekends, females are more likely to choose the walking states, and males tend to be in the vigorous status. For the adult group, weekdays were balanced between take notice and connect statuses for females, and males were more socially active, whereas on weekends. However, most chose walking state; there was a slight increase in the choice of vigorous status among females and a decrease among males. For the older adult group, walking and take notice states predominated on weekdays, while sedentary states were added on weekends, and take notice was equal to connect states. This demonstrates the typical behavioural differences between weekdays and weekends at different ages.

4.4. Correlation analysis

4.4.1. Effects of relevant variables on activity types

In this statistical test, we used Pearson's chi-square, the likelihood ratio and the linear correlation.

The chi-square value: This value represents the difference between the observed frequencies and the expected frequencies. The larger the value, the more significant the difference between the two. Asymptotic significance (two-sided): a *p*-value used to determine whether the relationship between two categorical variables is significant or not. In social science research, *p*-values less than 0.05 are usually statistically significant.

The **Table 10** above analyses the type of activity (cycling, using phone, dog walking) as being individually influenced by various factors, where SES differentiates the four parks versus size and the influence of different age groups, gender, and ethnicity on the type of activity is analysed. Overall, the effect of different parks on activity type was significant. Moreover, the significance of gender on the choice of activity type is higher than age group higher than race. The most significant value is the effect of park SES.

Table 10. Chi-square test table for influencing factors of activity types.

	Large or Small		**High or Low**		**Generation**		**Gender**		**Race**	
	value	**Significane (two-sided)**	**value**	**Significane (two-sided)**	**value**	**Significane (two-side)**	**value**	**Significance (two-sided)**	**value**	**Significane (two-sided)**
Pearson chi square	28.542	0.000	63.761	0.000	19.347	0.013	24.025	0.000	7.126	0.028
likelihood ratio	43.707	0.000	86.410	0.000	18.577	0.017	24.022	0.000	6.648	0.036
linear association	27.089	0.000	62.227	0.000	10.505	0.001	23.373	0.000	7.029	0.008

From **Table 11** we found that, there was a significant correlation between park size and activity choice, with a Pearson's chi-square value of 28.542, a likelihood ratio of 43.707, and a linear correlation of 27.089. Large parks were beautiful for cycling, which was not observed in small parks, and was also related to whether or not parks agreed to allow bicycles in. In contrast, the association between park SES and activity choice was more significant, with a Pearson's chi-square value of 63.761. Dog walking was significantly more common in parks with a high SES while cycling and using the phone were more common in parks with a low SES. The correlation between different age groups and activity choice was moderate, with 19.347, 18.577, and 10.505 values. In particular, the adult age group shifted predominantly from cycling and using phone to dog walking.

Table 11. Count cross-tabulation of influencing factors by type of activity.

Count Crosstab		Large or Small		High or Low		Generation					Gender		Race	
		Large	Small	High	Low	Infant	Child	Teen	Adult	Older Adult	Female	Male	White	Non-White
type of activity	Cycling	62	0	0	62	1	4	4	50	3	0	62	0	62
	Using phone	43	14	21	36	x	0	2	51	3	21	36	21	36
	Dog walking	146	74	124	96	0	2	13	176	29	124	96	124	96

In contrast, the correlation between gender and activity choice was similar to that of age groups, with values of 24.025, 24.022, and 23.373, mainly indicating that males were more likely to favour cycling and phone use. It mainly shows that males prefer cycling and using phone, while females prefer dog walking. As for race and activity choice, the correlation is the lowest among the five factors, with values of 7.126, 6.648, and 7.029. Whites mainly engage in dog walking and using phone, while non-Whites mainly engage in cycling. Overall, park size and SES were the two main factors influencing activity choice, while age, gender, and race also had some association with activity choice.

4.4.2. Effect of relevant variables on PA level

The above **Table 12** analyzes the individual influences of PA levels (S, waling, vigorous) on multiple factors, among which the four parks are differentiated by SES and size, and the effects of different age groups, genders, and races on PA levels are analyzed. The impact of different UGS on PA and health. Overall, the effect of different parks, i.e., different UGSs, on PA levels was significant. And gender has a significant effect on the choice of activity type than age group than race. The largest value is the effect of different age groups, indicating that there are large differences in PA levels between different age groups.

Table 12. Chi-square test table for influencing factors of PA level.

	Large or Small		High or Low		Generation		Gender		Race	
	value	Significance (two-sided)	value	Significance (two-sided)	value	Significance (two-sided)	value	Significance (two-sided)	value	Significance (two-sided)
Pearson chi square	15.776	0.000	33.853	0.000	489.980	0.000	44.467	0.000	4.280	0.118
likelihood ratio	16.727	0.000	33.657	0.000	356.563	0.000	43.554	0.000	4.058	0.131
linear association	5.691	0.017	0.013	0.910	5.016	0.025	11.072	0.001	0.635	0.426

From **Table 13** we found that, park size was significantly associated with PA levels, with larger parks attracting more people to be physically active, with a Pearson's cardinality value of 15.776, and some people in larger parks switching from walking activity levels to sedentary levels. And the SES of the parks also had a significant effect on activity choices, with a Pearson's cardinality value of 33.853, with parks with a high SES having predominantly walking activity levels. Parks with a low SES having sedentary levels and vigorous levels were more selected. Age is strongly correlated with activity levels, with significant differences in selection by

age, with Infant being predominantly sedentary and walking activity levels gradually becoming dominant with age. In contrast, vigorous activity levels are almost non-existent in the older adult group. Gender was also associated with activity levels, with females choosing walking activity levels predominantly. At the same time, males were more likely to choose vigorous state, and females made more visits to the park. Relatively, race was not significantly associated with activity levels, but cultural and lifestyle differences may still influence park activity choices. These analyses reveal how park characteristics and people's social attributes influence their park activity habits.

Table 13. Count cross-tabulation of factors influencing PA level.

Count Crosstab		Large or Small		High or Low		Generation					Gender		Race	
		Large	Small	High	Low	Infant	Child	Teen	Adult	Older Adult	Female	Male	White	Non-White
type of activity	S	150	43	87	106	50	10	8	104	21	111	82	161	31
	W	587	348	587	348	5	72	48	709	99	631	308	833	103
	V	154	81	110	125	1	91	34	106	3	103	131	190	29

4.4.3. Influence of related variables on state

The **Table 14** above analyses the activity status, the degree of interaction with the outside world (take notice, connect) is influenced by a variety of factors individually, in which the four parks are differentiated by SES and size, and the influence of different age groups, gender and race on the state of activity is analysed. Overall, the effect of parks with different SES on the state of people in the parks was significant. At the same time, gender was more significant than age group in choosing the type of activity, and park size and ethnicity were not significant in this difference. The most considerable value is the effect of different age groups, indicating a significant difference in activity status. Based on the chi-square test data, an in-depth study was conducted to examine the effects of park size, SES, and visitors' age, gender, and race on activity status.

Table 14. Table of Chi-square test for factors influencing activity status.

	Large or Small		High or Low		Generation		Gender		Race	
	value	Significane (two-sided)	value	Significane (two-sided)	value	Significane (two-side)	value	Significance (two-sided)	value	Significane (two-sided)
Pearson chi square	0.058	0.810	19.284	0.000	70.749	0.000	13.627	0.000	0.178	0.673
likelihood ratio	0.058	0.810	19.309	0.000	72.225	0.000	13.634	0.000	0.178	0.673
linear association	0.058	0.810	19.270	0.000	40.237	0.000	13.616	0.000	0.178	0.674

From **Table 15** we found that, the association between park size and activity status was not significant. Although intuitively, larger parks may attract more activity due to their amenities and space, the data needed to prove that size was the determining factor. Comparatively, park SES was significantly associated with

activity status, with a Pearson's chi-square value of 19.284. People in park areas with a high SES tended to interact more with nature. In contrast, parks with a low SES would interact more with people, possibly influenced by park amenities and residents' free time. Age also strongly affected activity status, with the child and teen groups favouring interaction with people and the adult group favouring interaction with nature. Concerning gender, females predominantly chose the activity state of interacting with nature, whereas males were likelier to choose to interact with people. However, race had the weakest correlation with activity status, and although cultural and community background may influence activity habits, race was not a significant determinant. These data reveal that other social and personal factors play a crucial role in determining park activity states in addition to park size.

Table 15. Count cross-tabulation of factors influencing activity status.

Count Crosstab		**Large or Small**		**High or Low**		**Generation**					**Gender**		**Race**	
		Large	Small	High	Low	Infant	Child	Teen	Adult	Older Adult	Female	Male	White	Non-White
activity status	TN	490	217	545	162	19	49	26	531	82	479	230	637	72
	C	453	195	430	218	14	124	61	388	59	375	273	583	61

5. Discussion & conclusions

5.1. Chapter introduction

In this chapter, the study revisits the initial research questions and explains the findings. The findings are explained in the context of UGS area, SES, gender, race, and age group. They are then compared with previous studies to identify similarities and differences. Substantiating rationales for these are also provided. After reviewing the completed study, the strengths and limitations are summarised to serve as a reference for related follow-up research and to address and avoid any shortcomings. Finally, the study is summarised.

5.2. Discussion

5.2.1. Outcomes

This study examines the mediators of PA and health in UGS. The research questions focus on the following: What qualitative factors in UGSs are associated with PA? Is there a relationship between demographic characteristics of the population, such as gender, age, ethnicity and PA, and how do they affect PA? This study's findings obtained through mixed methods (qualitative and quantitative research) are presented in CHAPTER 4. The facilities, environment, size, and socio-economic status of the UGS influence the type and level of PA. The age and gender of the population are also associated with significant differences in response to the type and level of PA. However, ethnicity only shows a significant difference when selecting the activity type. The research outcomes are explained in further detail below.

5.2.2. Interpretation

The UGS quality assessment and incivility assessment results indicate that better environments attract more people and that Harrison Park offers the best environment with the least incivility. It draws in the most people (37%), including the most take notice and connect. This is in line with previous research, which concluded a positive correlation between the presence of green and open recreational spaces and pedestrian activity (Li et al., 2005). The results also indicate that Harrison Park and Pilrig Park feature more facilities than Orchard Park and Granton Crescent Park and offer a wider range of activities as well as higher activity levels. This finding is consistent with previous research by Akpinar and Cankurt (2017), who showed that people living near UGSs with more amenities might engage in public activities more frequently. In this research we also found that picnic areas increase PA levels in UGSs. Pilrig Park is the only one of the four parks with a picnic area, and it has the highest percentage of people who engage in vigorous state. The percentage of people engaging in vigorous state is also higher than in other parks.

The findings indicate that differentiating parks by size has a significant effect on the number of active people, the type of activity, and the level of activity. This outcome aligns with the previous finding that larger parks tend to attract more people for all activities (Cohen et al., 2007). Larger parks also appear to provide more activity types. However, this research shows that that park size has only a small effect on vigorous state, whereas smaller parks have more people choosing walking and fewer choosing sedentary. These conclusions are also consistent with previous results by Wang et al. (2019), who found that the probability of residents choosing a lower frequency of activity increases as the area of green space increases. This may be because larger green spaces offer additional resting areas and opportunities for various activities. In contrast, smaller green spaces tend to be limited to a single recreational exercise type. With regard to activity status, the size of the parks is unexpectedly consistent despite the possibility that larger parks might attract more attention and activities due to their diverse facilities and rich spatial environments. One could argue that larger parks may attract more people to engage in activities like socialising, given their greater diversity of facilities and environments. However, in this research, the results indicate that park size is not a key determinant of whether people are active or sedentary.

This study also found that within parks situated in areas characterized by high SES, the population exhibited a propensity toward adopting healthier lifestyles. This was evidenced by a greater preference for activities such as dog walking, engaging in moderate walking levels of PA, and an increase in the prevalence of take notice. These factors, in turn, contributed to a modest extension of the duration of stay within the UGS. These findings align seamlessly with the observations made by Jun et al. (2017), who suggest that residents with higher incomes tend to dedicate more time to leisure activities in the UGS. More specifically, this research shows that locals, which are characterized by lower SES, demonstrated a more prevalent display of connect behaviour. On the one hand, it is evident that UGS situated within areas of low socioeconomic status often intersect with an environment characterized by a

scarcity of resources and the prevalence of behaviours that might be considered uncivilized. This can lead to parts of the take notice population to turn to connect.

On the other hand, this research shows that the proportion of non-whites is relatively high in areas with low socio-economic status, and previous studies have suggested that populations in Western countries prefer to participate in UGS in smaller groups (Elmendorf et al., 2005; Larondelle et al., 2014; Peters et al., 2010). However, Schetke et al. (2016) found that Asian populations typically travelled to UGS with family and friends to engage in group activities. Drawing parallels, the study conducted by Gobster's (2005) revealed that there exists a distinction in the time allocation for family group field trips and activities between Asians and Hispanics. Moreover, it was observed that within low-SES UGSs containing substantial non-white populations, there is an increased potential for engaging in community-oriented activities.

We also found that the age of the population also significantly affects the nature, intensity, and condition of their activities, with the exception of the infant stage, where autonomy in choice is limited. Teens, for example, are more likely to choose more intensive activities and show more desire to socialise. During adulthood, however, choosing walking over sedentary tends to occur more frequently, and there is a higher inclination to interact with nature. The older adult phase closely resembles the adult stage, albeit with a more limited range of available options to engage in vigorous state. In contrast to previous reports, the level of PA performed in UGS gradually decreases with increasing age. Moreover, some studies also suggested that the frequency of PA increases with age (Wang et al., 2019). The underlying rational for this difference can be attributed to the findings of Wang et al.'s (2019) study. For example, activities such as playing chess and walking on gravel, which are less intense and mainly favoured by older people, were included in the calculation of the PA frequency. In reality, however, the health impacts associated with lower-intensity PA were not as pronounced as suggested in these conclusions.

Regarding the gender of the population, there were significant differences in the activity type, activity level, and activity status. Females tended to show more mature habits and were more orientated towards adult activity levels and status. This meant that they were engaging in walking and take notice more often. This finding is also consistent with previous reports where the number of females participating in UGS was higher than that of males. In addition, female citizens, generally, had more free time than their male counterparts (Kaczynski et al., 2008).

In this research, the ethnicity of the population differed significantly only with respect to different activity types. For example, cycling was found to be an activity type only found in the non-white population. The white population, however, preferred dog walking. In the case of Pilrig Park, because bicycles were allowed to pass through, a significant proportion of the takeaway workers also entered the area, for example. Consequently, the proportion of cycling non-white population increased. While discernible variations in activity levels and activity status based on population demographics were absent, it remains plausible that the park activity patterns of individuals from distinct ethnic backgrounds could still be influenced by factors such as ethnicity, culture, habitus, and neighbourhood context. Discrepancies are evident

within prior research, as illustrated by European studies wherein a lower presence of older adults was noted within urban park settings (Evenson et al., 2016). This finding is consistent with the present study, where only a few older adults (21%) were observed. However, there may be differences between cities with different characteristics in different regions. For example, Wang et al. (2019) argue that older people dominate the PA group in China because older people in China have more time to retire and are more focused on enjoying life. Hence, while the impact of ethnicity may not attain statistical significance within the scope of this study, it remains imperative for city managers to take into account diverse cultures and traditions. This approach ensures the creation of a universally inclusive and welcoming environment within UGS, catering to the needs of all individuals.

5.2.3. Strengths and limitations

Several strengths are inherent in this study. First, a tested and reliable environmental assessment tool (EARPS Mini) and a suitable observation tool (MOHAWk) were used to assess and record observations of the site, and questionnaires or interviews (which are prone to recollection bias and personality differences) could be avoided. This was done to ensure the authenticity and reliability of the data collection process. Second, factors such as area size, socio-economic status and extrapolated visitors were controlled in the selection of UGSs to facilitate the comparison of control variables in a cross-sectional manner. The same area was selected for observation, and four observers went to four different parks simultaneously for two weeks to differentiate between weekdays and weekends. These observers proceeded with their tasks even on rainy days to minimise the effect of weather variables and ensure the robustness of the data. Third, the four observers were trained on the relevant observation tools prior to the observation, and all four had past experience using similar observation tools. In this way, any differences between observers could be resolved through discussion. Fourth, this study also recorded two extra behaviours, take notice and connect, during data collection on PA. Although these two behaviours do not intuitively reflect the level of PA, they reflect the connection between people and between people and urban grass spaces. As a result, more perspectives on the relationship between residents, USG, and PA are provided. Fifth, for the purpose of data analysis, this study was divided into three groups of activity types, PA level and activity status, which clarified the relationship between different activities and the influence of UGS areas, socio-economic status, gender, race and age group.

Certain limitations are associated with this study: First, although direct field observation can reduce the effect of individual differences, some obstacles with respect to information collection remain. Examples include PA frequency and PA duration, and we can consider adding observation records of PA duration in subsequent studies, and the data collection on the attributes of individuals entering the site relies on the observer's demographic characteristics, leading to potential inaccuracies in categorising information such as age. One can mitigate these inaccuracies by incorporating on-site inquiries or questionnaires to address this. Second, the study encompassed a two-week observational period, and the data comparison followed a cross-sectional approach. This approach poses challenges in

adequately substantiating long-term effects. Therefore, it is advisable to incorporate relevant longitudinal studies in future research endeavours to augment the study's comprehensiveness. Third, no data on consistency between observers was collected, and although all observers were trained, there were unavoidable individual differences. Fourth, when selecting the observation area and choosing the observation point, although we tried to avoid blocking the observers' view, some trees on the site still affected the observation. Fifth, people entering the park could not be identified as residents of the neighbourhood as no background checks were carried out, and the possible presence of participants from more distant areas likely had a significant impact on the data analysis.

5.3. Conclusions

The distinct correlation between UGS and PA, serving as a platform for residents to partake in PA, profoundly impacts the well-being of the inhabitants. The results of this study and several other studies show that the facilities, environment, park size, and socio-economic status (SES) of UGSs affect the type of PA and improve the intensity of PA. Moreover, it also affects the take notice and the connect of the residents. This underscores the significance of directing efforts toward increasing and refining UGS facilities and surroundings.

Observing the correlation between UGS and residents' PA enables, on the one hand, the development of pertinent interventions through the investigation of potential dominant influences in a particular region to enhance UGS acquisition equity. However, by focusing on two observational components—environment and communication—this new observational tool, MOHAWk, raises the significance of the resident-environment connection in UGS assessment and offers a fresh line of inquiry and point of reference for subsequent study.

Notably, UGSs of varying sizes, as well as socio-economic status, require distinct considerations in their enhancement and differentiation. Gender and age demographics also have an impact on PA, whereas the impact of race is not significant. To more effectively meet the various needs of various demographic groups for UGS, future research should consider these factors and concentrate on how to implement the specific measures derived from the above conclusions, as well as the most accurate and efficient ways of collecting these data. These methods and measures are crucial for creating customised and captivating campaign strategies that cater to various groups' distinct preferences and interests.

Some of the study's limitations should be addressed in subsequent research, including improving data collection techniques, examining the advantages and disadvantages of multiple data collection strategies, conducting a more thorough evaluation of the observation area's state, and enhancing the consistency of the participants' pertinent backgrounds. Public health experts, UGS administrators, sociologists, psychologists, urban planners, architects, landscape architects, and public safety officials must effectively collaborate to create workable interventions to increase UGS residents' PA levels.

Author contributions: Conceptualization, WZ; methodology, WZ; software, WZ; validation, WZ, YL and PG; formal analysis, WZ.; investigation, WZ and YL;

resources, XG; data curation, WZ and YL; writing—original draft preparation, WZ, YL and PG; writing—review and editing, WZ, YL and XG; visualization, WZ; supervision, XG; project administration, XG. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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