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Impact of summer heat on urban park visitation, perceived health and ecosystem service appreciation

Nadja Kabisch[1,2,*], Roland Kraemer[1,3], Oskar Masztalerz[1], Jan Hemmerling[1], Catharina Püffel[1,4], Dagmar Haase[1,5]

1 Humboldt-Universität zu Berlin, Department of Geography, Unter den Linden 6, 10099 Berlin, Germany, nadja.kabisch@geo.hu-berlin.de
2 Helmholtz Centre for Environmental Research – UFZ, Department of Urban and Environmental Sociology, Permoserstraße 15, 04318 Leipzig, Germany
3 Helmholtz Centre for Environmental Research – UFZ, Department Monitoring and Exploration Technologies, Permoserstraße 15, 04318 Leipzig, Germany
4 Institute for Ecological Economy Research, Potsdamer Str. 105, 10785 Berlin, Germany
5 Helmholtz Centre for Environmental Research – UFZ, Department Computational Landscape Ecology, Permoserstraße 15, 04318 Leipzig, Germany

Abstract

Urbanization, environmental change and ageing are putting urban health at risk. In many cities, heat stress is projected to increase. Urban green spaces may be an important resource to strengthen the resilience of city dwellers. We conducted a questionnaire survey in two structurally distinct parks in Leipzig, Germany, on hot summer days in 2019. We assessed the respondents' activity patterns, satisfaction with the existing infrastructure, heat-related health impairment, changes in park use during heat waves and evaluation of the role of parks in coping with heat stress. We found that the old-growth, tree-rich park was used significantly more frequently for experiencing nature, while the newer, less-tree rich park developed on a former railway-brownfield site was used more often for socializing and having BBQs and picnics. Satisfaction with available drinking fountains and public toilets was generally low. Safety was assessed as satisfactory in general but significantly less satisfactory by female respondents. The heat stress summary score indicating heat-related health impairment was significantly higher for participants at the newer park. A high share of respondents stated that they used parks during heat waves as frequently as usual in the summer (46%), while some respondents stated that they adapted their park use behaviour (18%), e.g., by coming later in the evening. Regarding the participants' responses about the role of parks under hot conditions, we matched 138 statements to several regulating and cultural ecosystem services, and we found cooling and recreation to be mentioned most often. We concluded that green space planning should diminish usage barriers, such as insufficient lighting and insufficient sanitary infrastructure, to ensure equal park use opportunities for all city dwellers. Specific local environmental and sociocultural conditions, changing environments and climate adaptation must be considered. To maintain ecological processes and functions and to cope with climate change, urban planning should preserve older parks with a large amount of tree coverage while respecting demands for particular built infrastructure.

Keywords

Heat, urban green space, perception, public health, central European, behaviour, Leipzig, social survey

1. Introduction

Across Europe, heat waves and droughts are becoming more frequent and severe, whereby heat exposure is intensified, especially in densely built-up and highly artificial urban environments (European Environment Agency, 2020; Guerreiro et al., 2018). Some models predict up to 58,000 additional heat-related deaths per year from 2025 to 2055 under the 2°C scenario and define Central and Southern Europe as focus areas for excess mortality (Ciscar et al., 2018). In addition, many cities increasingly suffer from expanding populations and higher population densities, particularly in inner-city neighbourhoods (Cortinovis et al., 2019), which is often accompanied by land take and increases in car traffic and air pollution that directly compromise the health of city dwellers (World Health Organization, 2017, 2010). Evidence suggests that long-term exposure to air pollution may also increase susceptibility to respiratory infections (Fattorini and Regoli, 2020). In addition, high population densities and urban ways of life may increase the stress levels of city dwellers due to psychological mechanisms and social dynamics such as isolation or exclusion (Adli, 2011).

In light of these health-threatening conditions, urban green spaces may provide important ecosystem services that mitigate these challenges for urban dwellers (Dobbs et al., 2014; Konijnendijk et al., 2013; Larondelle et al., 2014; McDonald et al., 2018). Urban green spaces provide the potential for cooling, air quality regulation, traffic noise mitigation, density-related stress relief and enhancement of mental well-being (Cohen et al., 2007; Grote et al., 2016; Nowak et al., 2018). Furthermore, green spaces may function as meeting places and spaces for physical activities and enable city dwellers to interact with the natural environment (Bratman et al., 2019; Dickinson and Hobbs, 2017). Overall, urban green spaces have the potential to increase individual health resources and resilience against environmental stressors, which is particularly relevant in the context of environmental and climate change (Hunter et al., 2019; Kabisch et al., 2017). Planetary health crises such as the COVID-19 pandemic have illustrated the interdependencies of human beings and natural ecosystems. During periods when virus containment measures were being implemented, the pandemic clearly showed the benefits of close-by green spaces for people using them to participate in safe outdoor activities with their households and families and to practise sports to maintain their health and well-being (Venter et al., 2020; Xie et al., 2020).

To quantify the multiple benefits of urban green spaces, studies commonly apply ecosystem service assessments (Brzoska and Spāģe, 2020; Derkzen et al., 2015; Tavares et al., 2019). Such assessments are mostly based on citywide land use and land cover data (Arnold et al., 2018; Feltynowski et al., 2018; Larondelle et al., 2014; Łaszkiewicz et al., 2020; Mexia et al., 2018; Smith et al., 2017) and focus on greenspace availability and relevance for children and older people (Flowers et al., 2019; Kabisch et al., 2017; Knight et al., 2018; Schicketanz et al., 2018; Sikorska et al., 2020). Studies also use multimethod approaches by combining local environmental condition measures with social science surveys (Charoenkit and Piyathamrongchai, 2019; Kabisch and Kraemer, 2020). Reviews have shown that most assessments focus on regulating ecosystem services (Brzoska and Spāģe, 2020; Tavares et al., 2019) and cultural ecosystem services (Dickinson and Hobbs, 2017; Nesbitt et al., 2017). Nesbitt et al. (2017) highlighted some studies that focused on perceptions and valuations of urban green spaces in terms of perceived health and social well-being. In this context, clear research gaps were identified, including the value of urban green spaces for improving social health (Andersson et al., 2019; Nesbitt et al., 2017; Wolch et al., 2014). In this context, social health is understood to include feelings of integration, a sense of community and perceived and experienced safety, the latter of which is particularly relevant for women. In addition, all of these aspects may increase individual resilience towards environmental stressors (Sreetheran and van den Bosch, 2014).

Despite the numerous studies addressing urban ecosystem services, little is known about how environmental and climate change affect the provision and use of ecosystem services. This might be

due to the relative novelty of severe and long-lasting heat and drought conditions in some areas and because of methodological difficulties in associating the wellbeing-related benefits of urban green spaces under changing environmental conditions (Lafortezza et al., 2009). Furthermore, there is a lack of research on how park availability (Nesbitt et al., 2017) as well as the use and perception of natural elements and built facilities (Kabisch and Kraemer, 2020) may differ under heat and drought conditions.

The aim of this study is to assess park visitors' activity patterns, their satisfaction with park infrastructure and the role of parks in visitor health under hot conditions in the summer. Using the results of a questionnaire survey conducted in two inner-city parks in Leipzig, Germany, under hot conditions during summer 2019, we assess how heat impairs perceived health, how visitors change their park use during heat waves and how they evaluate the importance of parks for their heat-related health changes. With the latter assessment, we aim to identify potential perceived ecosystem services that park visitors appreciate under hot conditions.

2. Methods

2.1 Study area

Leipzig is a large central European city with a current population of 601,668 (2019). The city has rapidly grown and gained nearly 100,000 additional residents in the last ten years (population in 2010: 508,775). The strong population increase is mostly due to net migration gain and natural population growth. Related urban development has rapidly changed the layout of the city in the last decade, with residential development taking place throughout the city. In the context of these processes, the City of Leipzig aims to maintain a significant share of urban green spaces. In doing so, the existing high diversity of infrastructure and vegetation characteristics among urban parks is intended to be preserved (Stadt Leipzig, 2017). In total, Leipzig's urban green spaces, including urban forests, parks, cemeteries and allotment gardens, total to 4,348 ha, which is 14.6% of the total city area (297.6 km²). However, the urban green space was severely impacted by two periods of summer heat and drought in 2018 and 2019, with high numbers of hot days with temperatures of 30°C or higher (29 days in 2018 and 25 days in 2019) and lower annual precipitation (338 mm in 2018 and 397 mm in 2019; Stadt Leipzig, 2021) compared to the long-term mean (511 mm).

We conducted our study in two inner-city parks in the eastern part of Leipzig, Friedenspark and Lene-Voigt-Park (Figure 1). The eastern part of the city has been characterised by particularly strong population dynamics in the last ten years. Many young and well-educated residents have immigrated to the area, and many neighbourhoods have been upgraded through renovations and the settlement of new enterprises. However, the eastern part of Leipzig has less available public green space than the western part of the city, where an extensive riparian forest is located. Hence, urban parks are particularly important in the eastern part, where green space alternatives are scarce. We selected the two examined parks because of their proximity to each other and their different origins and development: Friedenspark is a long-standing park with a total size of 17.5 ha that was a cemetery in the 19th century and that has an extensive and mature stock of trees (61% tree cover); Lene-Voigt-Park is a newly created park on a former railway brownfield that was opened to the public in 2004 and that is characterized by open space (ca. 40% grass and 20% tree cover) as well as a larger variety of play and sports facilities (Kraemer & Kabisch, 2020, Table 1). While the two parks are situated relatively close to each other, with the shortest distance between them being only 500 metres, the surrounding urban environmental structures of the two parks are different. While the residential blocks around Friedenspark are mostly made up of business areas and the campus of the city's university hospital, Lene-Voigt-Park is surrounded by residential Wilhelminian-time "Gründerzeit" houses.

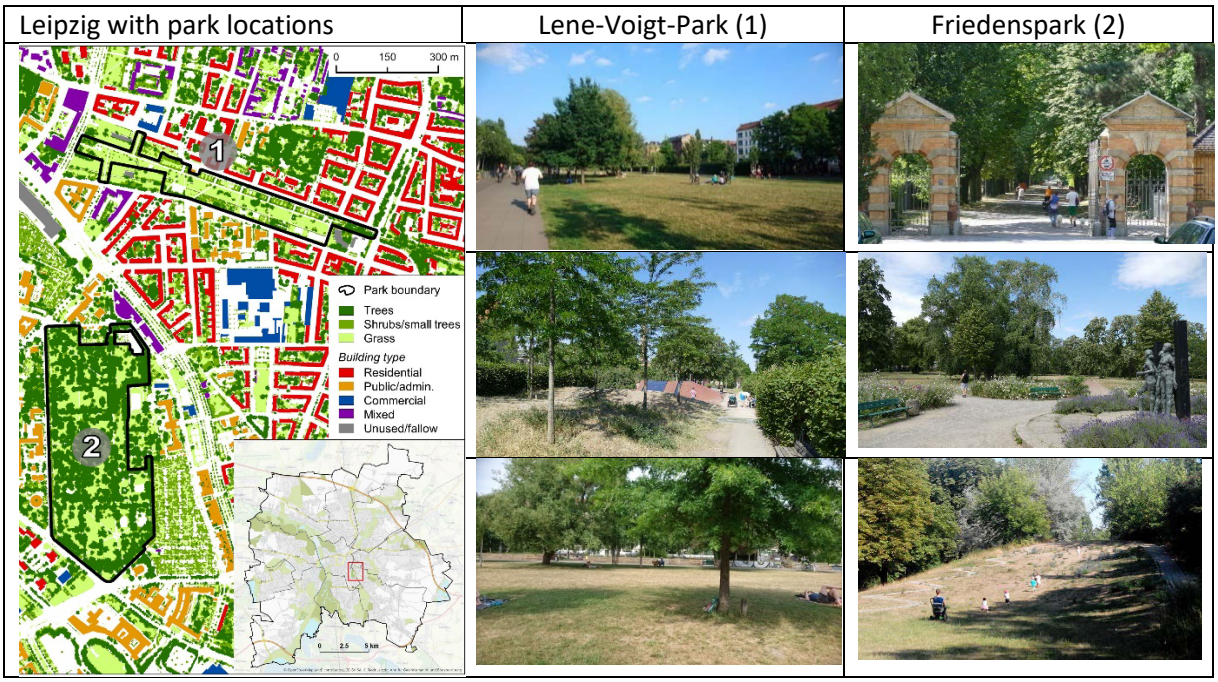

Figure 1. Location of the two examined parks in the city of Leipzig; 1 – Lene-Voigt-Park, 2 – Friedenspark. Pictures taken by the authors in July 2019 (Map data sources: Banzhaf and Kollai, 2018, GeoBasis-DE/BKG 2018).

Table 1. Main characteristics and facilities of Lene-Voigt-Park and Friedenspark.

	Lene-Voigt-Park	Friedenspark
Used as a public park since	2004/2005	1983
Size (ha)	5.78	17.48
Mean tree height (m)	7.99	13.19
Share of trees (%)	0.14	0.61
Share of lawns/grass (%)	0.41	0.24
Share unvegetated area (%)	0.21	0.03
Share vegetated area (%)	0.78	0.96
Number of playgrounds	3	1
Number of sports fields*	5	6
Lighting	Extensive	None
Water fountain	0	1
Toilets	0	0

*_including_ table tennis, soccer, beach volleyball, and basketball

2.2 Questionnaire survey

A questionnaire survey was planned to examine general park activity patterns and satisfaction with park infrastructure, vegetation elements and aspects of the park environment to identify the respondents' perceived health impairment due to heat and the role of parks in relation to health under hot conditions in the summer. A pre-test was performed during a hot period in July 2018 (n=28) to

evaluate and optimize the practicability of the questionnaire. The main survey was conducted on 24th and 25th July 2019.

The temperature and air humidity values for both days of the survey are summarized in Table 2 based on data from temperature measurement stations in and around the parks. For the temperature measurement, we adapted the approach used by a climate measurement campaign that was initially run in 2018 (Kabisch and Kraemer, 2020). The in situ climate measurements included a total of 18 stationary measuring devices installed across both parks and 13 sensors placed in the nearby built-up area recording air temperature (all sensors) and air humidity (only the park sensors) in 5-min intervals at 2 m height, which is commonly used as the standard air temperature measurement height.

Both days of the survey were hot, with maximum air temperature values of 35.4°C in Friedenspark and 38.3°C in Lene-Voigt-Park. The average daily temperatures were the lowest in Friedenspark, at 26.5°C on the first day and 27.9°C on the second day, compared to 28.3°C and 29.5°C in Lene-Voigt-Park, respectively, and slightly higher values in the nearby urban environment (29°C and 30.3°C, respectively).

Table 2. Temperature (T) and relative air humidity (RH) values in the Friedenspark (FP), the Lene-Voigt-Park (LVP) and the close-by built-up urban area (Urban) on both days of the survey.

		FP		LVP		Urban
		T in °C	RH in %	T in °C	RH in %	T in °C
24.07.2019	Mean	26.5	48.0	28.3	45.7	29.0
	Min	17.3	26.7	17.9	25.3	18.7
	Max	34.3	81.5	37.8	76.7	36.5
25.07.2019	Mean	27.9	41.4	29.5	40.2	30.3
	Min	18.9	21.1	19.3	20.3	20.5
	Max	35.4	67.3	38.3	65.6	37.5

Each day, five team members (interviewers) approached visitors at the two parks from 10 a.m. to 8 p.m. to capture different usage times and visitors. To minimize selection bias, every person who entered the interviewers' range was asked to participate in the survey. Active movement of the interviewers through the parks also allowed them to interview resting people. Overall, the interviewers managed to approach most of the park visitors on both study days.

The persons who agreed to participate in our survey were asked various Likert-scale questions about their usual visitation and usage behaviour at the respective park (e.g., distance of most frequent starting point for a visit in the park, frequency of visits, frequency of various activities; see Supplementary Material Figure 1 for the questionnaire translated into English language). Furthermore, following the approach by Wagner et al. (2020), satisfaction with park facilities was assessed with regard to safety, park maintenance, noise, and park infrastructure (benches, toilets, and playgrounds) with Likert scales. Perceived health impairment was quantitatively assessed by using a five-point Likert scale ranging from 0 (not at all) to 4 (very strong) concerning each of the following symptoms: headache, sleep problems, exhaustion, concentration problems and cardiovascular problems. The role of parks in health during heat waves was assessed with open questions to elicit the most comprehensive range of answers. Finally, sociodemographic information such as age, gender and highest education level was obtained.

2.3 Data processing

The data were manually transferred from the completed questionnaires into SPSS software (IBM Statistics SPSS 24.0). A heat stress summary score was calculated for each participant by summing the Likert-scale values for the five heat-related symptoms.

The answers to the open question on changes in park visitation patterns during heat waves were classified into the categories “equal park use”, “more park use”, “less park use”, and “adapted park use”. General descriptive statistical analyses and non-parametric tests were performed to analyse the data and to identify statistically significant differences in the respondents’ visitation patterns, satisfaction and health impairments by park and by gender. The Mann-Whitney U-test was used to test for significant differences, with the threshold set at $p < 0.05$. Pearson’s chi-square test was used to identify significant differences in satisfaction with park facilities by gender, also using a threshold of $p < 0.05$.

3. Results

3.1 Characteristics of the study participants

Our sample consisted of 176 respondents who were equally distributed over both parks (Table 3). The mean age of the respondents was 31 years in Friedenspark and 28 years in Lene-Voigt-Park, with the majority being female in both parks. Furthermore, the vast majority of the respondents (85.2% in Friedenspark and 88.6% in Lene-Voigt-Park) had a post-secondary degree as their highest level of formal education, which is much higher than the percentage for Leipzig (48%, (Stadt Leipzig, 2019)) and higher than the percentages for the “Zentrum Südost” district, in which Friedenspark is located (*Zentrum Südost*, 72%), and the “Reudnitz” district, in which Lene-Voigt-Park is located (*Reudnitz*, 70%, Stadt Leipzig, 2019). Most participants indicated that when they visited Lene-Voigt-Park, they most often came from directly adjacent neighbourhoods. The respondents in Friedenspark came from a slightly larger catchment area (Figure 2).

Table 3. Participants' characteristics across Friedenspark and Lene-Voigt-Park.

	Friedenspark (%)	Lene-Voigt-Park (%)	Total (%)
Total	88 (100.0)	88 (100.0)	176 (100.0)
Age category			
< 18	2 (2.3)	0 (0.0)	2 (1.1)
18-23	26 (29.5)	25 (28.4)	51 (29.0)
24-30	28 (31.8)	40 (45.5)	68 (38.6)
31-45	18 (20.5)	18 (20.5)	36 (20.5)
46-60	7 (8.0)	3 (3.4)	10 (5.7)
> 60	6 (6.8)	1 (1.1)	7 (4.0)
unknown	1 (1.1)	1 (1.1)	2 (1.1)
Gender			
Female	56 (63.6)	50 (56.8)	106 (60.2)
Male	31 (35.2)	38 (43.2)	69 (39.2)
Inter / diverse	1 (1.1)	0 (0.0)	1 (0.6)
Highest level of school education			
Higher education entrance qualification (A-levels; “Abitur”)	75 (85.2)	78 (88.6)	153 (86.9)
Secondary education	12 (13.6)	7 (8.0)	19 (10.8)
other	1 (1.1)	3 (3.4)	4 (2.3)

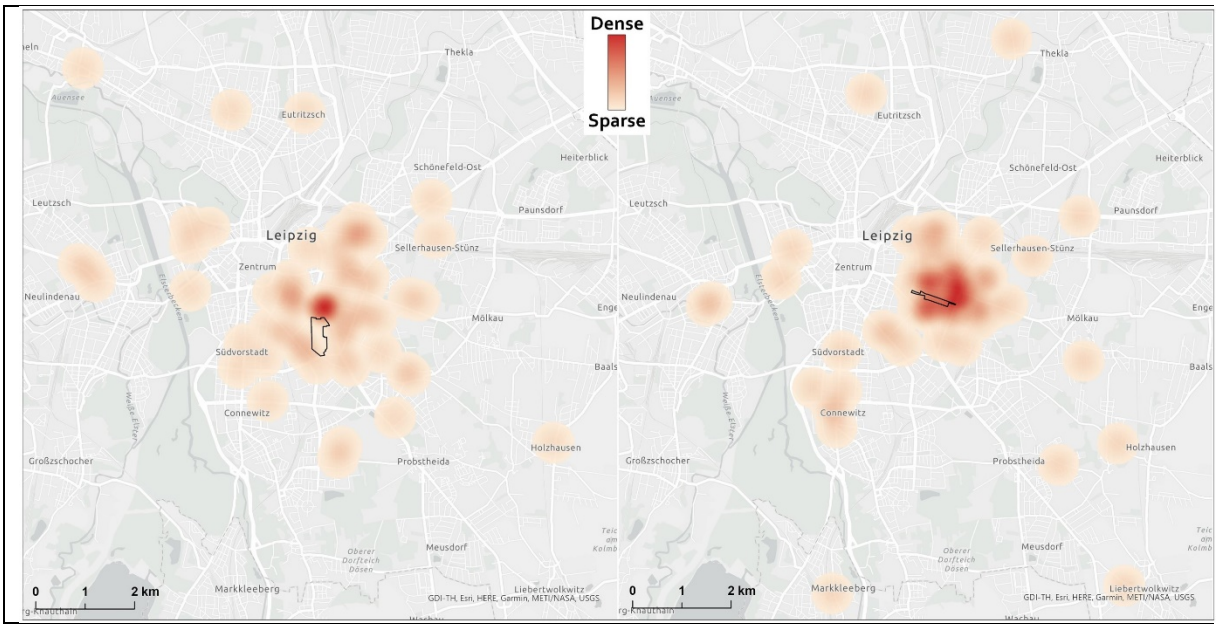

Figure 2. Heat map (point density) of the indicated starting points for a visit in Friedenspark (left) and Lene-Voigt-Park (right).

3.2 Usage patterns and satisfaction with infrastructure

The most frequently conducted activities in both parks were relaxing, experiencing nature, walking and strolling and socializing, but the order of frequency varied between the parks (Figure 3). In addition, there were some significant differences between the parks: Friedenspark was visited significantly more to experience nature (Friedenspark 1.64 vs. Lene-Voigt-Park 1.02), while Lene-Voigt-Park was visited significantly more often for socializing (Friedenspark 1.19 vs. Lene-Voigt-Park 1.92) and having joint barbeques (BBQ) and picnics (Friedenspark 0.44 vs. Lene-Voigt-Park 0.80).

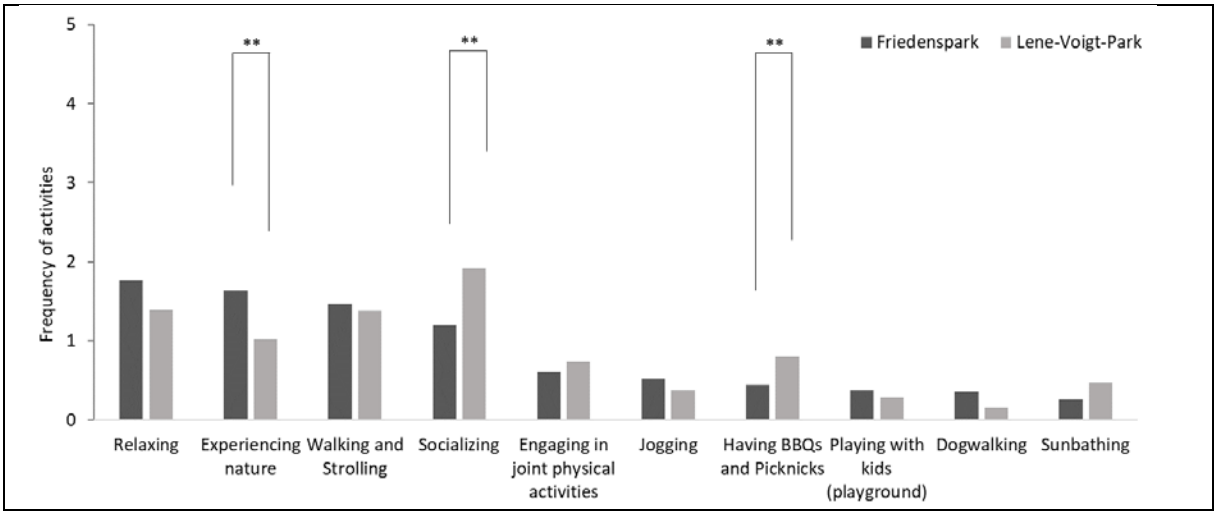

*Figure 3. Average frequency of activities in Friedenspark and Lene-Voigt-Park rated on a 5-point Likert scale (0 = (almost) never, 1 = once to several times a year, 2 = several times a month, 3 = once a week, 4 = several times a week, 5 = daily). ** shows significant differences with p< 0.05.*

When we asked the participants about their satisfaction with different aspects of the built park infrastructure and the flora and fauna (Figure 4), we found that the overall average satisfaction with safety (3.38 in Friedenspark and 3.38 in Lene-Voigt-Park), the social environment (3.33 and 3.34), play facilities (3.15 and 3.26) and the number of benches (3.02 and 2.89) was high, while satisfaction with public toilets (1.26 and 1.21) and drinking fountains (1.26 and 1.24) was generally low. We also identified significant differences between the two parks. Satisfaction with cleanliness (3.15 vs. 2.51), noise level (3.35 vs. 2.98) and flora and fauna (3.02 vs. 1.90) was significantly higher in Friedenspark, whereas satisfaction with lighting (2.00 in the Friedenspark vs. 3.61 in the Lene-Voigt-Park) and accessibility (3.32 vs. 3.76) in the park was significantly higher in Lene-Voigt-Park. We also analysed whether park-specific satisfaction with park facilities differed by gender. The results of the chi-square-test statistics showed that only satisfaction with safety was significantly different, with women being less satisfied than men, particularly in Friedenspark ($p<0.05$, Supplementary Material Table 1).

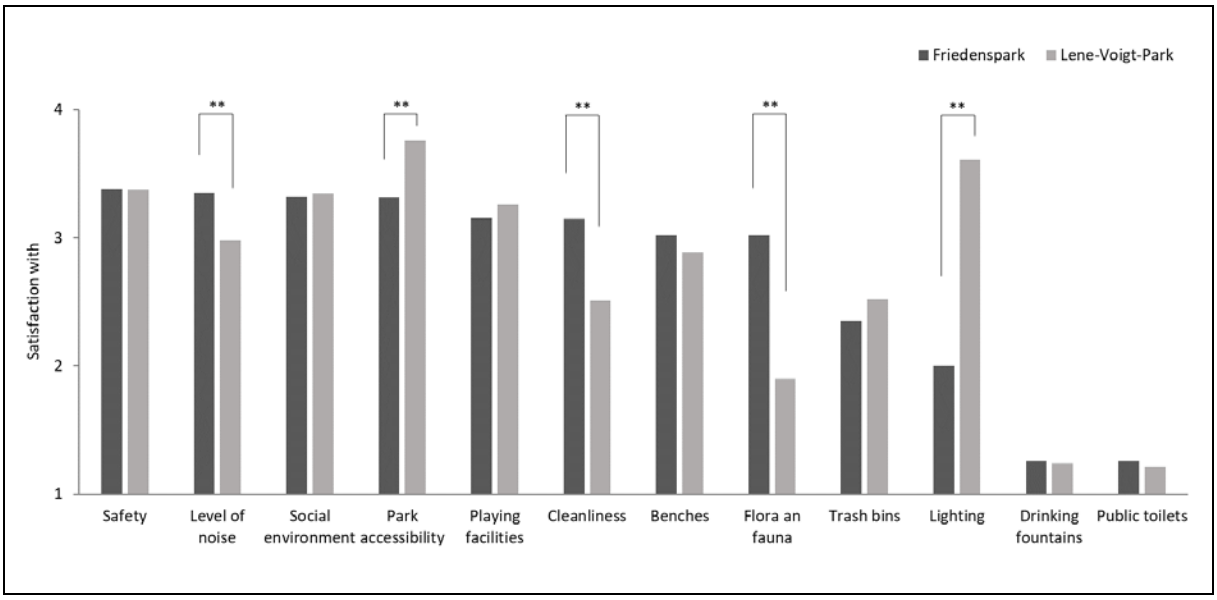

Figure 4. Satisfaction with the built, natural and contextual park infrastructure at Friedenspark and Lene-Voigt-Park rated on a Likert scale from 1 (low) to 4 (high). ** *shows significant differences with p< 0.05.*

3.3 Heat-related changes in park use and health impairment

When asked about changes in their general park use under hot conditions, a high share of the respondents (46.0%) indicated that they did not change their park use behaviour (Figure 5). One-fifth (21.0%) mentioned that they went to parks more often, and only 15.3% mentioned that they went less often. A total of 17.6% indicated that they adapted the time of day of their park visits, e.g., by coming later in the evening.

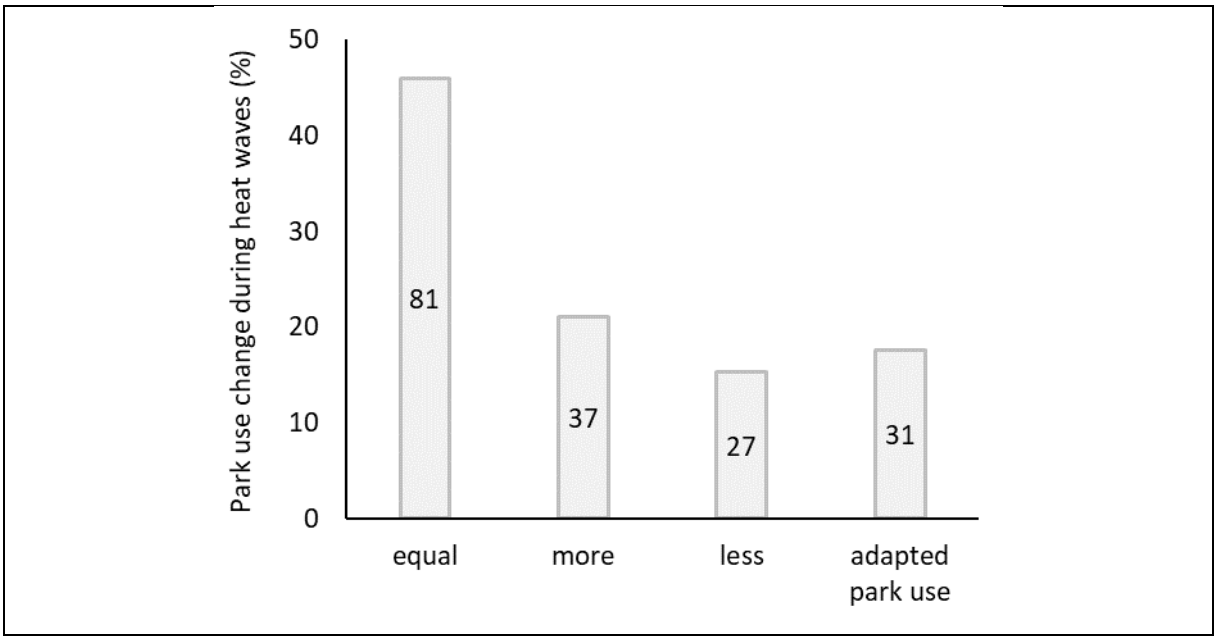

Figure 5. Percentages of changes in park use during heat waves among the participants at Friedenspark and Lene-Voigt-Park (total frequency values in bars).

On average, the respondents reported general health impairment during heat waves in terms of all of the symptoms presented on the questionnaire (Figure 6). Impairments such as concentration problems, exhaustion and sleep problems were rated higher than impairments such as headache and cardiovascular problems. However, the levels of impairment did not differ significantly depending on the park in which the respondents were approached. However, the average values of the heat stress summary score differed significantly depending on the park in which the participants were approached, with the participants in Lene-Voigt-Park scoring higher (9.2 in Friedenspark and 10.3 in Lene-Voigt-Park).

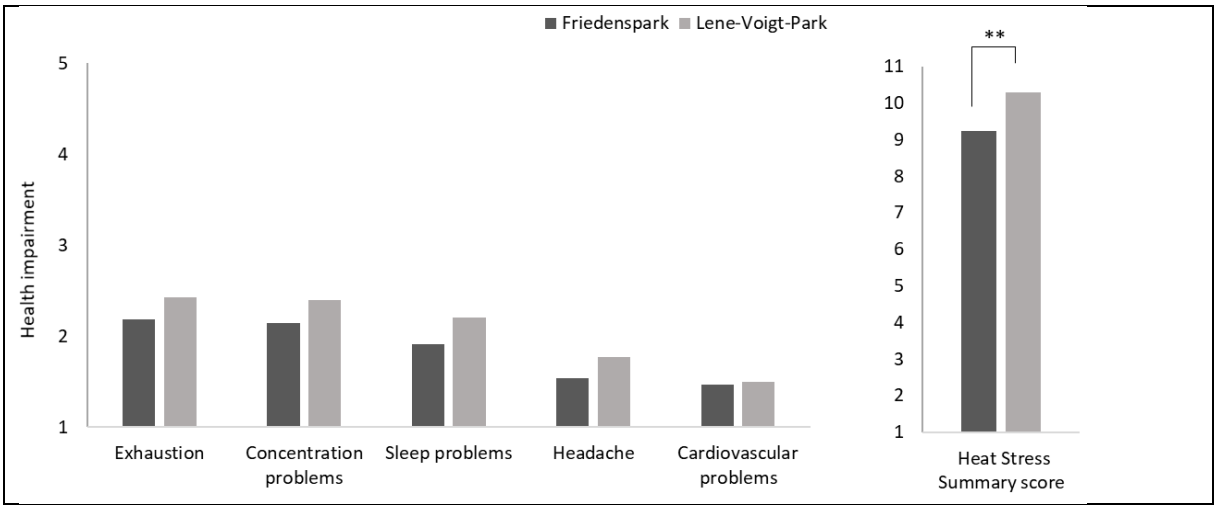

*Figure 6. Health impairment during heat waves among respondents at Friedenspark and Lene-Voigt-Park based on different symptoms and based on the heat stress summary score, calculated as the sum of the symptom ratings on a Likert scale from 1 (not at all) to 5 (very strong). ** shows significant differences with p< 0.05.*

3.4 Appreciation of ecosystem services under hot conditions

When asked the participants an open question about the role that park visits played under hot conditions, we received a variety of answers. We grouped and matched the answers to the different

ecosystem services (Table 4, incl. quotation examples). We obtained a higher total number of ecosystem services-related responses at Friedenspark than at Lene-Voigt-Park (95 vs. 43). The respondents at Friedenspark most frequently referred to the cooling function of parks, i.e., regulating ecosystem services. Other responses were related to the air purification and noise mitigation functions of parks, with both of these functions mentioned more often at Friedenspark. Several responses were related to cultural ecosystem services, mainly related to recreation in both parks. A number of respondents, especially at Friedenspark, also referred to experiencing nature. Furthermore, some responses from Friedenspark related to the provision of a place to concentrate as a cultural ecosystem service. Here, some of the respondents indicated that they came to the park for learning purposes.

Table 4. Answers to the question for the impact of parks on heat-related health changes. Shown is the frequency of quotes related to different ecosystem services with corresponding ecosystem services categories and example quotations.

Ecosystem service category	Ecosystem service	Example quotations	Frequency of related quotations	
			Friedenspark	Lene-Voigt-Park
Regulating	Cooling	"Park provides shade", "In the park it is cooler than at home"	40	15
	Air purification	"Fresh air", "Improved air condition in the park"	6	3
	Noise mitigation	"Park provides quietness", "Here it is quiet compared to city noise"	7	2
Cultural	Recreation	"We can recreate and relax in the park", "Being in the park is like a break", "One can recover form daily stress"	26	16
	Concentration	"Here I can do my learning"	3	-
	Socialising	"I meet friends in the park", "Social contacts"	2	4
	Nature experience	"I appreciate the trees", "I like to be in nature"	11	3

4. Discussion

We conducted a questionnaire survey in two different parks in Leipzig, Germany, to analyse park activity patterns; satisfaction with park infrastructure, vegetation elements and park environment aspects; health impairment due to heat; and the role of parks related to health under hot conditions in the summer. We found that Friedenspark was significantly more frequently used to experience nature and that Lene-Voigt-Park was significantly more frequently used to socialize as well as have BBQs and picnics. Furthermore, the participants were significantly more satisfied with the noise level, cleanliness and flora and fauna at Friedenspark and with the accessibility and lighting at Lene-Voigt-Park. Satisfaction with drinking fountains and public toilets was generally low. Safety was generally satisfactory but there was significantly less satisfaction for female participants. The heat stress summary score based on several heat-related health symptoms was significantly higher in participants who were approached at Lene-Voigt-Park. A high share of respondents stated that they used parks equally during heat waves as they did during the rest of the summer, while some used them more frequently, some used them less frequently and some used them later in the evening. The responses to the question on the role of parks in relation to health under hot conditions in the summer were matched to several regulating (cooling, air purification, noise mitigation) and cultural (recreation, concentration, socializing, nature experience) ecosystem services, with cooling and recreation most frequently corresponding to the responses obtained in both parks.

As we aimed to analyse park use and satisfaction under hot summer conditions, the generally low satisfaction with drinking fountains indicates need for action, particularly due to the increasing number of hot summer days and the cooling function of parks. Unsatisfactory sanitary infrastructure may also constitute a barrier for park use in general and under hot conditions in particular, especially for older people (Enssle and Kabisch, 2020). Furthermore, unsatisfactory sanitary infrastructure may place visitors at additional risk of heat-related illness during or after a park visit on hot days, as they might drink insufficient amounts of water.

Although we found generally high satisfaction with safety in both parks, we identified significant differences by gender. In particular, in Friedenspark, women were significantly less satisfied with safety. Women might have lower perceived security in public urban areas in general during the day; however, women's safety concerns when visiting parks have been identified in other studies as well (Maruthaveeran and van den Bosch, 2015). Lindgren and Nilsen (2012) showed that women felt particularly less comfortable in parks at darker times of day due to poor lighting. In general, lighting was found to be a key park attribute for park-based physical activity (Zhang et al., 2019). In contrast to Lene-Voigt-Park, Friedenspark has no night lighting at all, which might explain the significantly lower satisfaction with lighting there. Others have shown that sufficient lighting is particularly important to parents when they visit parks with their children (Mani et al., 2012). With regard to the result that during heat waves, some people used parks later in the evening, insufficient lighting might create a usage barrier, particularly for women and families. However, requests for improved lighting need to be addressed carefully, as parks and urban green areas are "islands of darkness" that support biodiversity in cities (Sanders et al., 2020).

Although general health impairment due to different heat-related symptoms was affirmed by most of the respondents in both parks, the participants at Lene-Voigt-Park showed a significantly higher heat stress summary score. In addition to having different user groups in the two parks due to differences in usage opportunities and the provided ecosystem services as described above, this difference in the heat stress summary score might be explained by the influence of the environments of the two parks themselves, which provided the settings for the interviews. For example, compared to Friedenspark, Lene-Voigt-Park has higher daytime temperatures due to the open space, much lower vegetation/tree canopy coverage and a smaller amount of shaded spaces (Kabisch and Kraemer, 2020). More comfortable air-temperature conditions as well as the more natural environment in Friedenspark during the survey could have influenced the respondents' perceptions and responses. Park use and the recognized ecosystem services provided by a park clearly depend on the park structure and infrastructure. Friedenspark, with its high tree coverage, the lawn areas and more satisfying flora and fauna, is used for natural experiences significantly more frequently, while Lene-Voigt-Park, with its open areas, many sports, playing and seating facilities, is used for socializing as well as having BBQs and picnics significantly more often. In the summer heat, the different park characteristics and usages may complement each other to serve different recreational demands of different user groups at different times of day. Kabisch and Kraemer (2020) showed that different age groups also preferred dedicated areas in parks with specific characteristics. They found that young children frequented playgrounds and lawns, while older people preferred to sit on benches. Our sample showed a low share of older people, which might be related to the high daytime temperatures during the fieldwork. In their observational study, Kabisch and Kraemer (2020) also identified a comparatively low number of older people in general but also a significant reduction in the number of park users in all age groups at temperatures of 29.5°C or higher. Older people are more strongly impaired by higher temperatures (Conti et al., 2007) and therefore may avoid park visits under long-lasting hot conditions. Another reason for the small number of older people in both parks may have been the local urban structures

that the parks are embedded in, i.e., the university area close to Friedenspark and an increasingly upgraded neighbourhood with many young families around Lene-Voigt-Park (Ali et al., 2020).

The diversity and complementarity of recreational demands and park usages are also reflected by the perceived roles of parks in relation to heat-related health changes. All of the responses were matched to multiple ecosystem services. Hence, the parks seem to be strongly appreciated for their protective and health-promoting effects under hot conditions. Again, two complementary aspects can be identified, represented by regulating and cultural ecosystem services and their interplay. Cooling, recreation and natural experience were mentioned most. However, socialization and concentration may result from these services. Hence, carefully designed urban parks might strengthen both physical and mental resources and resilience in general as well as in regard to increasing heat stress, noise and air pollution due to environmental change and increased urban densities in particular. In a study conducted in two parks in Nicosia, Cyprus, the authors found that park users mainly practised physical exercises but also appreciated nature, socialization and the cooling function of the parks (Giannakis et al., 2016), similar to our study. However, in Nicosia, the cooling function seemed to be less recognized than the other benefits, which might be because the residents are adapted to local hot and dry conditions (Giannakis et al., 2016). This finding emphasizes the need to carefully plan a park design that is tailored to specific local environmental and sociocultural context conditions. A comparative study of park visitation behaviour in two cities in Italy (Bari, Milan) and the UK (Gateshead) showed higher park usage for physical activities such as jogging in Bari and Milan and higher park usage for walking in Gateshead (Lafortezza et al., 2009). Although the authors discussed cultural differences, again, adaptation and acclimation to hotter conditions may play an important role, and this possibility needs to be further investigated and considered.

Some participants at Friedenspark referred to the provision of a place to concentrate as a cultural ecosystem service during hot summer periods. The function of parks for learning and working purposes has not been fully recognized. The benefit for concentration may be related to the social health benefits of cultural ecosystem services, as outlined by Nesbitt et al. (2017). To date, only some studies have investigated the influence of urban green spaces as learning environments, and these studies mostly focused on school children. Using a qualitative research design, Chawla (2015) showed that natural areas promoted concentration, stress relief and relaxation in school children. Others showed that school grounds with higher levels of vegetation were experienced as more restorative by school children (Bagot et al., 2015). In a case-control study, Kelz et al. (2015) found that compared to the control groups, the intervention group of pupils aged thirteen to fifteen years showed significant increases in self-reported psychological well-being after schoolyard greening (Kelz et al., 2015). Further research on the function of public green spaces such as parks for studying and working may supplement the understanding of the role of parks for city dwellers.

Limitations and prospects for future research

Our aim was to assess park visitors' activity patterns, their satisfaction with infrastructure and the role of parks in relation to health under hot conditions through a questionnaire survey. For feasibility, we streamlined our capacities and focused on two consecutive days and a coherent and manageable survey area of two adjacent parks. The survey started at 10 a.m. and lasted until 8 p.m. on two weekdays. This timeslot may have excluded some visitor groups who came earlier in the morning or later in the evening. For future surveys, we suggest including earlier and later times of day on weekdays and weekends to capture various environmental settings and allow for a more comprehensive visitor profile.

Furthermore, we tried to target the most representative set of park visitors for the survey by aiming to ask all visitors at the parks to participate. However, we obviously could not approach persons who

were not at the park, perhaps precisely due to the high air temperatures. Long-term surveys that include lower-temperature periods (that may also ask heat-related questions) and city-wide (online) surveys that do not exclusively focus on pre-selected green spaces may be helpful in ensuring a more comprehensive evaluation of adaptation behaviour.

Finally, on-site surveys could be complemented with scale-crossing and near-real-time data recording provided, e.g., by social media (Ilieva and McPhearson, 2018) or data from sports tracking apps (Heikinheimo et al., 2020). Social media data such as those from Twitter may be used for comprehensive and longer-term park visitor counting and assessment (Hamstead et al., 2018). However, given the biases of user-generated data in terms of representativeness, data access, security and ethical use (Heikinheimo et al., 2020), on-site surveys based on social scientific approaches remain important for collecting detailed information about visitors' motives and their perceptions of health and wellbeing.

5. Conclusion

Urban health is currently at risk due to a variety of social and environmental challenges. In light of this, city dwellers' resilience might be strengthened by urban green spaces. In particular, regulating and cultural ecosystem services are appreciated by park users during heat waves and may complement each other. To provide equal access to urban parks as a health resource, green space planning should remove and avoid usage barriers, such as insufficient lighting. To meet the demands of different user groups and usage times, park planning should be inclusive and equally consider different usage preferences. The investigation of urban dwellers' perceptions, views and behaviour is vital for the development and implementation of urban green space policies and planning in response to global challenges. Therefore, specific local environmental and sociocultural conditions, changing environments and climate adaptation must be considered. In terms of adapting to climate change, urban planning efforts should consider maintaining older parks with large tree coverage to keep regulating ecosystem services such as cooling while respecting the demands for cultural ecosystem services such as experiencing nature and socializing. This goal may require co-production processes in which ecosystem service provisioning and human demands are jointly considered in planning processes (Fischer and Eastwood, 2016). The function of public green spaces for studying and working may supplement the understanding of the role of parks.

Increasing population densities in cities and planetary health crises such as the COVID-19 pandemic have clearly shown the demand for and relevance of green urban environments for city residents – particularly under heat and drought conditions. Planning for parks should thus consider the demands of different user groups to maintain health and well-being.

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Supplementary material

*Table 1: Chi-square test statistics for satisfaction by gender (f... female, m... male). Significant coefficients in bolt with **highlight significant (p<0.05) and *significant (p<0.1)*

Friedenspark									
	don't agree		**rather not agree**		**agree**		**fully agree**		**p**
Satisfaction	**f**	**m**	**f**	**m**	**f**	**m**	**f**	**m**	
Safety	0	0	6	0	28	12	22	17	**0.084***
Cleanliness	1	0	10	6	25	15	20	10	0.871
Level of noise	0	2	5	1	22	16	2	12	0.113
Benches	1	1	16	5	24	14	15	11	0.575
Public toilets	46	21	6	3	0	3	1	1	0.102
Trash bins	11	6	24	9	16	10	5	6	0.421
Drinking fountains	48	22	2	2	1	3	2	1	0.306
Lighting	18	14	19	6	11	7	5	2	0.451
Accessibility	2	2	11	2	13	7	29	18	0.419
Flora and fauna	3	0	8	10	27	13	18	8	0.157
Playing facilities	2	2	10	3	20	14	23	10	0.551
Social environment	2	0	2	0	24	22	26	6	**0.026****

LVP									
	don't agree		**rather not agree**		**agree**		**fully agree**		p
Satisfaction	**f**	**m**	**f**	**m**	**f**	**m**	**f**	**m**	
Safety	0	0	4	3	28	13	18	22	0.107
Cleanliness	4	4	25	11	20	515	1	8	**0.017****
Level of noise	2	0	7	10	30	17	9	10	0.184
Benches	3	3	18	9	15	11	114	15	0.562
Public toilets	44	30	4	4	1	1	1	1	0.944
Trash bins	6	6	24	11	13	11	7	10	0.266
Drinking fountains	43	29	4	4	1	2	1	1	0.779
Lighting	2	0	9	2	25	20	11	15	0.101
Accessibility	0	1	1	0	6	10	43	27	0.164
Flora and fauna	16	11	26	18	6	8	1	1	0.73
Playing facilities	1	1	7	3	21	15	17	19	0.579
Social environment	3	0	4	3	30	22	12	12	0.476