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Spatiotemporal Characteristics of Public Recreational Activity in Urban Green Space under Summer Heat

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Abstract: The urbanization process has contributed to the deterioration of the urban thermal environment and increased the frequency of heat waves in summer that damage public health. Urban green space is the space for the public to escape the summer heat. The cooling effect of urban green space (UGS) can encourage outdoor activities and enhance public health. Analysis of when and how the public utilizes UGS under summer heat can serve as a guide for UGS improvements. In this study, the Hot Spring Park in Fuzhou City, China was utilized as a case study to examine the characteristics of the public recreational behaviors and their influencing factors under summer heat. Results showed the following observations: (1) Canopy density and turf coverage played key roles in regulating the thermal environment. (2) UGS can accommodate multiple summertime behaviors with considerable spatiotemporal variations. (3) In the hot summer, the frequency of recreational activities in UGS was negatively correlated with temperature. Dynamic behaviors were significantly impacted by temperature. Older and younger groups were less heat-tolerant. Based on this, we propose countermeasures and suggestions that are tailored to the needs of urban residents and their behavior characteristics for the planning and management of urban parks in the summer heat.

Keywords: summer heat; thermal environment; recreational behavior; urban green space

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1. Introduction

Rapid urbanization has led to the expansion of built-up areas, and the heat island effect is gradually destroying the urban thermal environment [1–6]. Extreme summer heat threatens the health and well-being of city inhabitants [7–9]. City inhabitants are forced by the hot weather to remain indoors. In the long run, this tendency to stay indoors, which lowers exposure to nature, will cause urban residents to suffer from dizziness, headaches, colds, loss of appetite, and other symptoms, which will negatively affect their health [10]. According to research, healthful outdoor activities are more beneficial than indoor ones [11]. However, it is quite dangerous to participate in outdoor activities in the hot summer. During scorching days, the ability of the elderly to regulate body temperature is diminished, and mortality rates are significantly higher for those over 65 [12,13]. Further, children, particularly infants, are vulnerable to high air temperatures, and individuals with weakened immune systems are the most susceptible to heat-related hazards during heat waves [14,15].

Urban parks are vital for mitigating urban temperatures and improving urban microclimates due to their thermoregulatory capabilities [16,17]. Vegetation in urban parks decreases residents' exposure to heat through shading and stimulates activities for city residents [18,19]. Urban parks offer excellent activity places for city residents who have been indoors for an extended period of time, not only allowing people to engage in a range of activities in close proximity to nature but also mitigating the direct harm to human body caused by high temperatures. During certain periods of summertime months, outdoor areas are ideal for recreation [20–22]. As the pursuit of a healthy lifestyle by individuals becomes increasingly urgent, the demand for green open spaces in cities rises. The utilization efficiency of urban green space can be enhanced by analyzing how the public uses parkland in hot weather.

Previous studies on the thermal environment of urban parks in summer have mostly focused on the role of spatial elements and landscape structure in regulating the thermal environment in urban parks. The mechanisms of thermal environment and thermal comfort in urban parks have been the subject of fruitful research. Related studies indicate that the spatial structure of the park landscape and green space features can considerably influence the thermal environment of the park [23–25]. Landscape design elements such as plants and paving significantly impact microclimate and thermal comfort in the summer [26,27]. On the other hand, there has been much interest in studying the behavioral characteristics of urban park users and exploring the connotations of their needs for park environments [28,29]. Some scholars have suggested that urban park visitors are predominantly middle-aged and elderly and that they are motivated to relax, exercise, and be close to nature for leisure purposes. The fundamental behavioral characteristics of urban park users were also described [30,31]. Furthermore, it has been confirmed that urban park users engaged in different levels of activity in different environmental settings; people are more likely to exercise in plazas, walk on lawns, and stay sedentary in landscaped areas [32,33]. Evidence showed that the smaller the rigid pavement area, the simpler the spatial form and the more users engaging in static behaviors such as resting and sitting; the larger the rigid pavement area, the simpler the structure of the biotic community and the more users engaging in dynamic behaviors such as ball games [34,35]. In the context of global climate change, park environment is not the only factor influencing the behavior of urban park users. However, few studies have been undertaken to uncover the mechanisms between thermal environment and visitor recreational behaviors in urban parks under high temperature; thus, the intrinsic linkage between the thermal environment and recreational behaviors has not been well-established.

In light of global warming and the urban heat island effect, how to increase the use of urban parkland during high summer temperatures is a pressing concern in urban park planning. In 2017, the National Climate Center of the China Meteorological Administration released a list in which Fuzhou ranked second after Chongqing among Chinese cities with the hottest summer temperatures and was dubbed one of the new "Four Furnaces" by internet users [36,37]. Given the high summer temperatures in Fuzhou, how to slow down the deterioration of habitat, improve the environment of urban parks, and promote the frequency of outdoor activities in Fuzhou has become a pressing problem. The objectives of this study are (1) to investigate the characteristics of spatial and temporal changes in the summer thermal environment of Fuzhou Hot Spring Park and to analyze the association between temperature and landscape elements; (2) to observe the behavioral characteristics of urban park users in the summertime; (3) to study the impacts of thermal environments on park user behaviors; (4) to make recommendations for optimizing urban park environments and the facility layout in order to provide guidance and decision support for enhancing the summer appeal of urban parks.

2. Materials and Methods

2.1. Study Sites

Fuzhou has a typical subtropical monsoon climate, with an annual average temperature of 20–25 °C and a tendency to rise yearly. Since 2000, only one Chinese city, Chongqing, has been able to match Fuzhou's average extreme maximum summer temperature of

39 °C or higher [38]. Fuzhou Hot Spring Park is located in the heart of Fuzhou, surrounded by many residential communities (Figure 1). There are both artificial and natural landscape recreation spaces in the park. The Hot Springs Park is a comprehensive urban green space with recreational facilities such as arch fountains, playgrounds for kids, and other amenities [39,40].

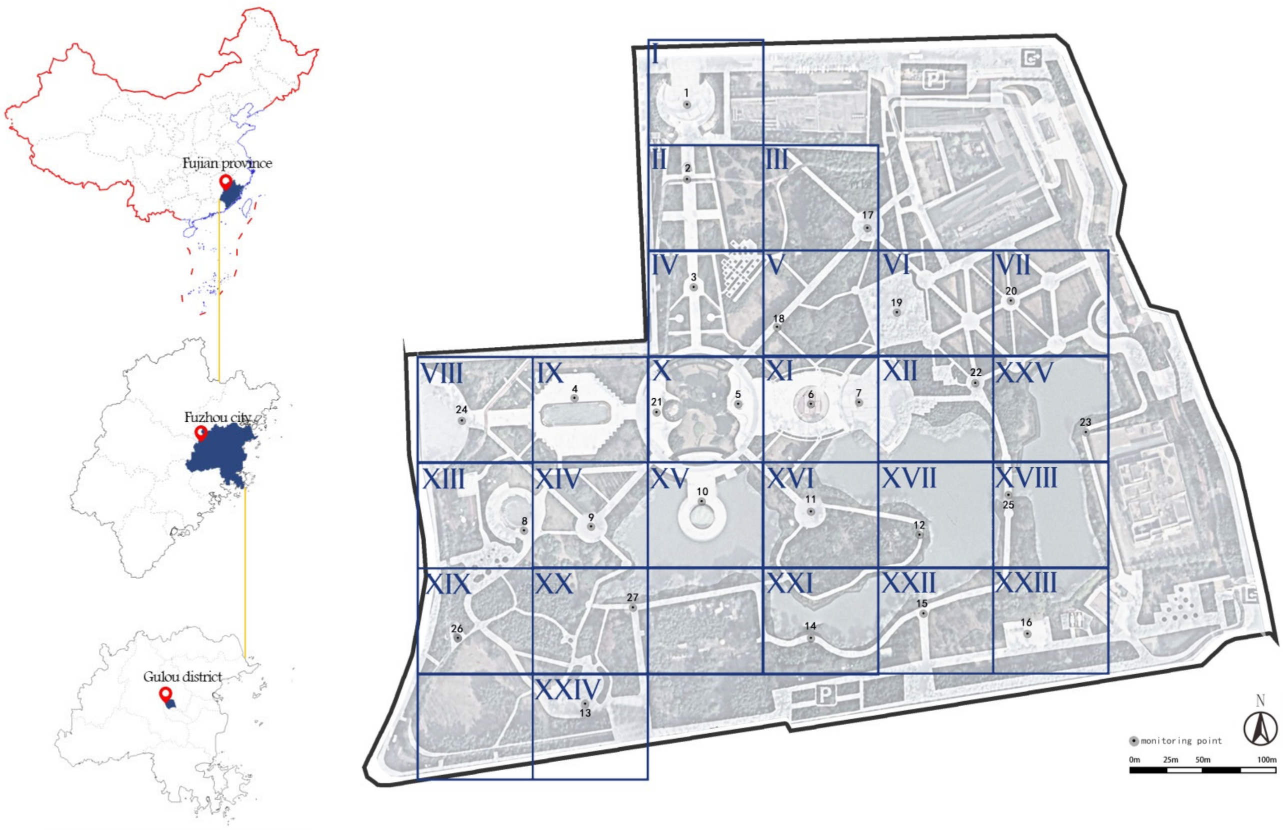


Figure 1. Area division and monitoring points of Hot Spring Park.

2.2. Data Collection

In this study, we divide the Hot Spring Park into 25 grids; each grid contains 1 monitoring point. Due to blind spots at some grids, 2 additional monitoring points were added (bringing the total up to 27) (Figure 1). The study period was 19–23 July 2021. From 6:00 and 22:00 (park operating hours), data were collected hourly. Referring to the time division standard published by the Meteorological Bureau and the actual sunset time, the observation period was partitioned into 6 sessions: early morning session (6:00–8:00), morning session (8:00–12:00), noon session (12:00–14:00), afternoon session (14:00–17:00), evening session (17:00–20:00), nighttime (20:00–22:00).

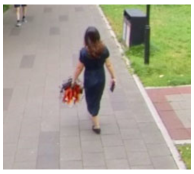
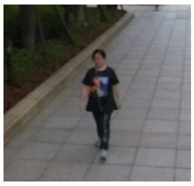
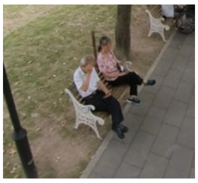
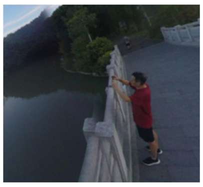
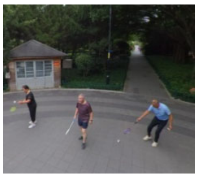
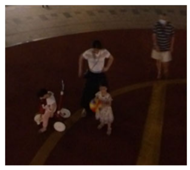
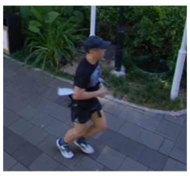
2.2.1. Temperature

Park temperature data were collected using the handheld weather meter Kestrel NK-5500. Every hour, two minutes of temperature data were collected at every monitoring point. Before the experiment, the instrument height was set to 1.5 m from the ground in accordance with the “Automatic Weather Station Observation Specification” and the microclimate ground data collection method. All instruments were calibrated to ensure consistent and accurate measurements. The weather meter provided approximately 2080 sets of temperature data for this study.

2.2.2. Public Recreational Behaviors

The park user data collection is based on the System for Observing Play and Recreation in Communities (SOPARC), a framework for observing human behaviors [41]. SOPARC is a reliable and valid observation tool for evaluating park-based public activities. Using this method, the observer can systematically and periodically view and record the demographic and environmental information of the target population without disturbing the observed subject [42,43]. The content of the original SOPARC record was revised to optimize the classification of recreational behavior types (Table 1) as per the research requirements.

Table 1. SOPARC record content.

Record Content				
Gender	 Female	 Male		
Age	 Children (0–17)	 Young adult (18–44)	 Middle-aged adult (45–59)	 Elderly (up to 60)
Type of activity	Static behaviors	 Relaxation (sitting, reading, closing eyes during meditation, etc.)	 Contact with nature (enjoying the nature, listening to sounds such as birdsong and running water, etc.)	 Social interaction (drinking tea, chatting, partying, playing chess, etc.)
	Dynamic behaviors	 Facility activities (activities dependent on various park facilities)	 Sports activities (sports-related activities such as ball games, dance, etc.)	 Leisure activities (chasing games, taking care of children, picnicking, etc.)
	Passing-by behaviors	 Walking	 Jogging	

Public behavior data were monitored and recorded utilizing panoramic equipment, which has the distinct advantage of 360° panorama display function when observing the public behaviors. The specific model of panoramic camera used in this study was the Insta360 One X. The ideal observation parameters for this panoramic equipment are 3 m in height and 0–15 m in viewing distance. Prior to the formal observation, pre observation is required to determine the optimal routes and monitoring points for each grid observation. Based on the principle of instantaneous sampling, photographs of public behavior were taken at each monitoring point in the grid. The recorded data include gender, age, behavior type, and behavior location. Behavioral and temperature data were collected simultaneously. Two trained observers were assigned to record and gather the SOPARC-based data with the panoramic equipment.

Using Kernel Density Estimation, the spatial distribution characteristics and differences in recreational behaviors are analyzed [44]. KDE (Kernel Density Estimation) is one of the approaches used to examine the distribution of point events, which can visually reflect the density distribution of visitors in various recreation locations. KDE is calculated as

$$f(x) = \sum_{i=1}^{n} \frac{k}{\pi x^2} \left(\frac{d_{ix}}{r} \right)$$

where $f(x)$ is the density of point x, r is the search radius, dix is the distance from point i to position x, and k is its weight value.

2.2.3. Landscape Spatial Element Data

Six landscape space elements that may affect the temperature in parks were selected and quantified: rigid pavement area percentage, water surface area percentage, turf coverage, canopy density, building vertical area, vegetation vertical area. The basic characteristics of some spatial elements are calculated by on-site surveys and Computer-Aided Design (CAD) topographic maps. Various landscape elements were extracted from the 360° panoramic photos, and the proportion of each landscape element in the monitoring points was computed using image semantic segmentation. In this study, the semantic segmentation model of Pyramid Scene Parsing Network is employed to recognize and classify targets in fish-eye photos. With fully convolutional networks, the PSP-Net Network model allows for pixel prediction, making it a practical system for advanced scene parsing and semantic segmentation. Figure 2 exhibits a diagram of the PSP-Net model structure. A variety of spatial components, such as sky, roads, water bodies, vegetation, and buildings, can be identified and calculated using this technology [45]. It provides data for further research into the basic characteristics of spatial landscape elements and spatial temperature.

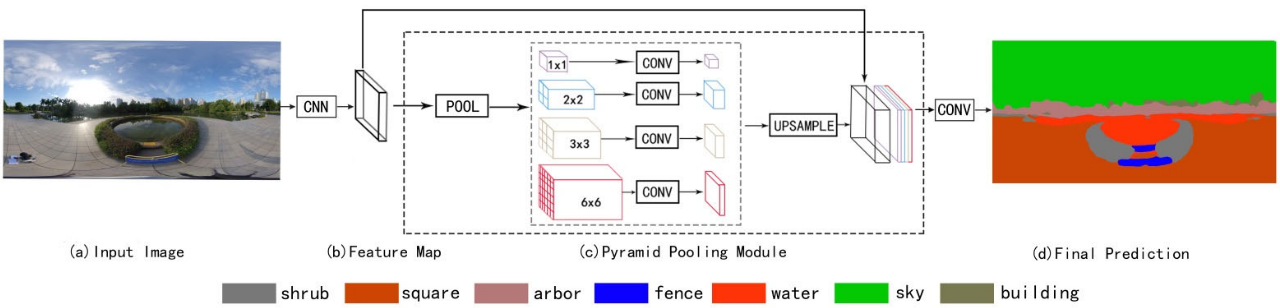


Figure 2. PSP-Net model structure [46].

2.3. Data Analysis

After obtaining quantitative data on temperature, public behaviors, and spatial elements of the landscape, this study applies statistical techniques to analyze their relevance. Cluster analysis was utilized to classify the monitoring points types based on temperature variations, and a significance test analysis was employed to analyze the differences between various landscape spatial characteristics. After using normal scores of transform in SPSS to transform data that did not satisfy a normal distribution, a multiple regression model with backward elimination was constructed to connect the thermal environment with landscape spatial factors. In addition, correlation analysis helps determine the temporal association between the number of park users, behavior types, and temperature. After identifying the time period in which the number of park users, behavior types, and temperature are significantly correlated, we used the multiple comparison analysis in analysis of variance (ANOVA) to examine the temperature preference for people of all ages and types of recreational behaviors in order to determine the differences in their temperature tolerance.

3. Results

3.1. Temperature Characteristics of Urban Parks in Summer

3.1.1. Temperature Temporal and Spatial Variation Characteristics

The daily average temperature at each monitoring location was 31.4 °C, with a maximum of 39.4 °C and a minimum of 26 °C. The daily temperature change displayed a clear unimodal shape. The average temperature was at its lowest in the early morning (26.9 °C) and climbed gradually after the accumulation phase from 7:00 to 12:00. The average temperature at all locations peaked at 35.2 °C during noon (12:00–14:00) and dropped slightly after 14:00. Despite minor differences, roughly similar curves were observed across all monitoring locations. The spatial distribution of summer temperatures in the park exhibits that high temperatures occurred near artificial landscape and rigid paved surfaces, whilst low temperatures occurred around natural landscape and water bodies (Figure 3).

Based on the surveys of temperature records, a cluster analysis was carried out on the 27 morning points (Figure 4). As shown in Figure 3, the average temperature of the three types of plots in descending order is Type II > Type III > Type I. A comparison of the landscape spatial characteristics across the three types of morning points (Table 2) showed significant differences in turf coverage, canopy density, and vegetation vertical area. To eliminate the effects of interdependence, p-values were adjusted by False Discovery Rate. Type I has a broader turf coverage, a greater vertical proportion of vegetation, and higher canopy density compared with the other two types. There was no significant difference between type II and type III in canopy density, but type II has a lower turf coverage and vegetation vertical area than type III (Figure 5). It is worth noting that the one-day temperature changes of both type I and type II showed a distinct unimodal pattern, but the temperature increase of type II was substantially less than that of type I. Despite its great fluctuation, type III was also characterized by a unimodal shape (Figure 3).

3.1.2. Thermal Environment and Landscape Element Association Characteristics

Temperature is the dependent variable Y, while the six landscape spatial elements (Table 3) are the independent variables. Before model building, we use Standard score (Z-score) to standardize the data. The multiple linear regression model was constructed with the following equation: $Y = 31.456 - 0.203X_3 - 0.271X_4$. The multiple correlation coefficient, represented by R in this model, is 0.872, indicating a highly significant correlation between the landscape spatial elements and the temperature. It is evident that landscape elements, such as vegetation, have a substantial impact on temperature regulation. In addition, park temperature can also be greatly affected by canopy density and turf coverage, and they appear to have a negative association. In other words, the park temperature drops as the canopy density and turf coverage increase. In contrast, canopy density contributes more to regulating the thermal environment than turf coverage, since canopy density refers to the proportion of space covered by the vertical projection of tree crowns. The proportion of park space covered by tree crowns has the greatest influence on temperature.

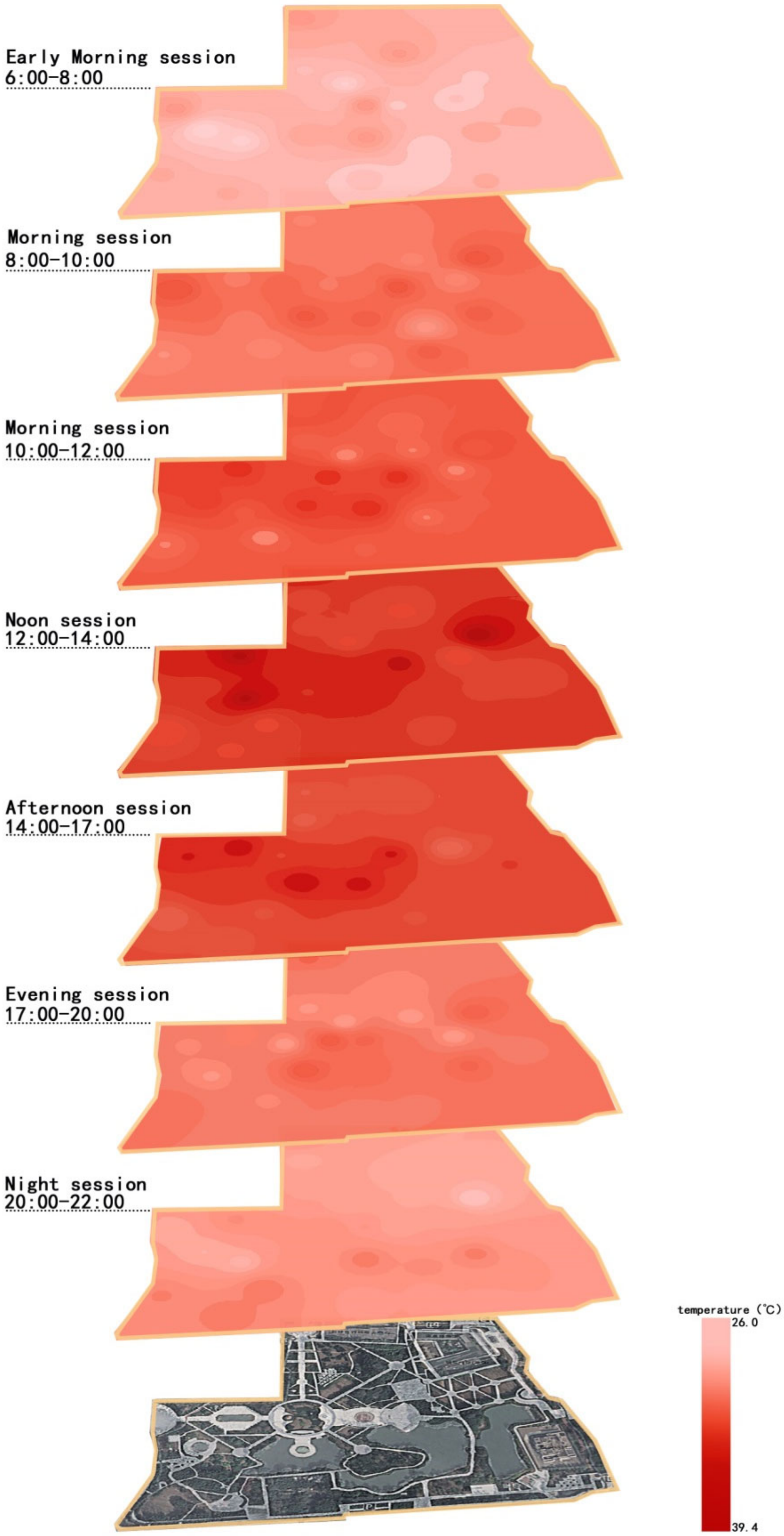


Figure 3. Temporal and spatial variation of park temperature.

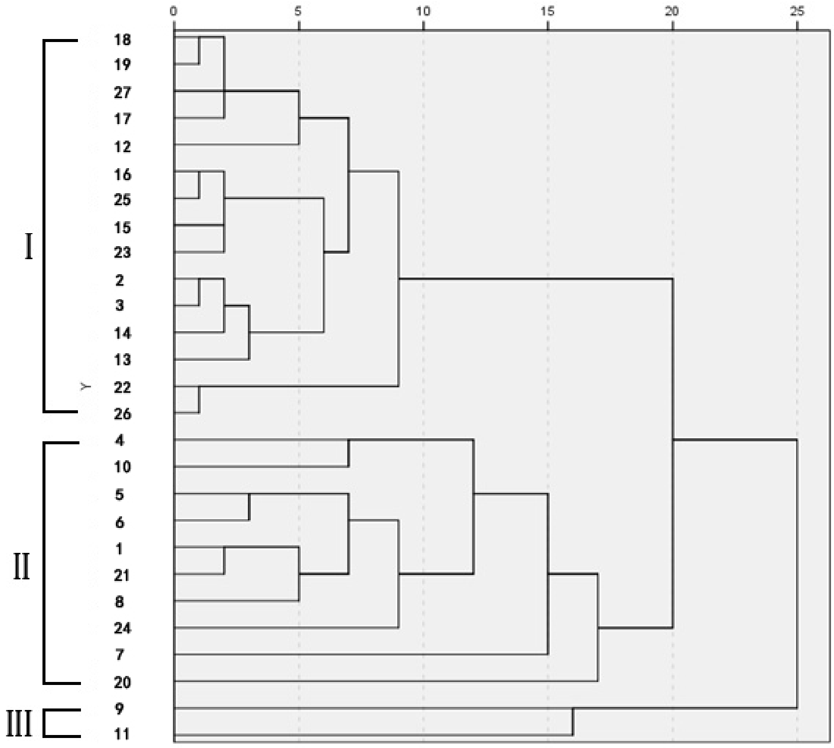


Figure 4. Clustering map of morning points.

Table 2. Landscape spatial characteristics of the three types of morning points.

Landscape Spatial Characteristics	Type I	Type II	Type III	F	Sig. (*p*-Value)
rigid pavement area percentage X_1	64.11 ± 20.64	89.61 ± 8.79	89.23 ± 0.53	3.670	0.087
water surface area percentage X_2	5.09 ± 10.39	3.54 ± 7.70	0.00 ± 0.00	0.233	0.634
turf coverage X_3 *	30.81 ± 18.32	6.85 ± 7.54	10.75 ± 0.78	4.572	0.016
canopy density X_4 **	58.96 ± 29.25	15.64 ± 7.33	15.70 ± 3.54	11.042	0.003
building vertical area X_5	0.48 ± 1.16	2.11 ± 3.63	0.19 ± 0.28	1.517	0.634
vegetation vertical area X_6 ***	32.45 ± 15.69	9.66 ± 2.58	11.45 ± 1.32	11.560	0.000

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (*p*-values adjusted by False Discovery Rate).

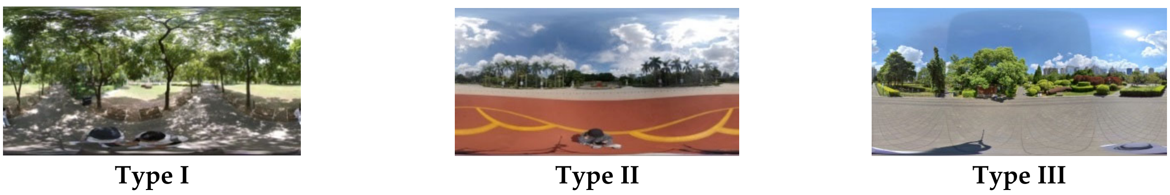


Figure 5. The panoramic view of three types of morning points.

Table 3. Regression model between thermal environment and landscape spatial elements.

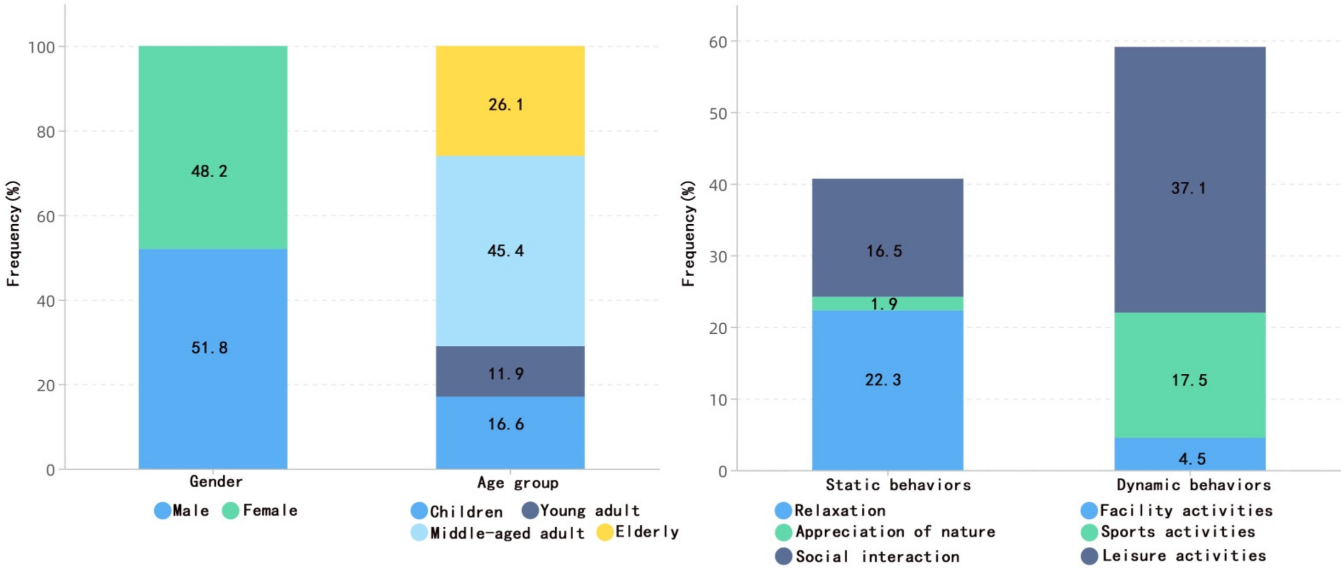
Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	Coefficient B	Standard Error	Beta		
(constant)	31.456	0.048		652.188	0.000
X_3	−0.203	0.078	−0.395	−2.595	0.016
X_4	−0.271	0.077	−0.534	−3.510	0.002

Note: Standard score (Z-score) was used to standardize the data.

3.2. Recreational Behaviors of Urban Park Visitors in Summer

3.2.1. Demographic Characteristics of Park Visitors

This study sampled approximately 4240 visitors. There were fewer females than males. A majority of visitors were adults, accounting for 83.3% of the total. The elderly comprised 26.1% of the population, while children accounted for only 16.6% (Figure 6a). The recreational behaviors of visitors were mainly for leisure, rest, and communication. The most frequent type of behavior—active and dynamic behavior, such as playing, taking photos, etc.—accounted for 37.1% of the total number of observed visitors. This type of behavior was predominantly exhibited by seniors, children, or in the form of "seniors + children companionship". Static behavior pattern (22.3%) is the second most popular type, which primarily involves sedentary activities such as sitting, reading, and meditation. Compared with static behaviors, more visitors engaged in dynamic behaviors, although the difference was insignificant. This finding suggests that parks can accommodate a wide range of behavior patterns (Figure 6b).



(**a**) (**b**)

Figure 6. (**a**) Percentage of basic attributes of visitors. (**b**) Percentage of behavioral patterns of visitors.

3.2.2. Temporal Characteristics of Park Visitors

Both on weekdays and weekends, the behavioral characteristics of park visitors during hot weather remained consistent throughout time. Visitors' arrival time followed a U-shaped pattern. The number of visitors rose slightly in the morning from 6:00 to 9:00 but dropped precipitously after 10:00 am. It did not reach its lowest point of the day until noon and afternoon. This number started to grow around 4:00 pm and continued an upward trend with fluctuation throughout the evening and night.

There are variations in the age distribution of visitors throughout the day. Although the overall number of visitors for both old and young groups showed a U-shaped pattern, the proportion of senior visitors in the early morning and morning was much greater than children visitors. This difference was inverted from 17:00 to 22:00, when there were more children than senior visitors, even though the discrepancy was smaller at night. The early morning workout routine explains why older visitors arrive at the park earlier. In contrast, younger visitors primarily visited the park in the evening, notably between 17:00 and 18:00. At this time, there were 147 children visitors present.

In terms of the temporal distribution of behavior types (Figure 7), more individuals engaged in dynamic and static behaviors at night than in the daytime under high summer temperatures. At night, there were more communication activities, free activities, and activities with park facilities. On the contrary, visitors preferred to spend the daytime, especially the morning, participating in static activities that could contact nature, such as enjoying natural scenes or dynamic activities that promote fitness. Visibility may be an important factor influencing behavioral patterns. More passing-by behaviors occurred during the day than at night, with much fewer joggers than walkers. The peak hours for jogging and walking were between 7:00 and 9:00 am.

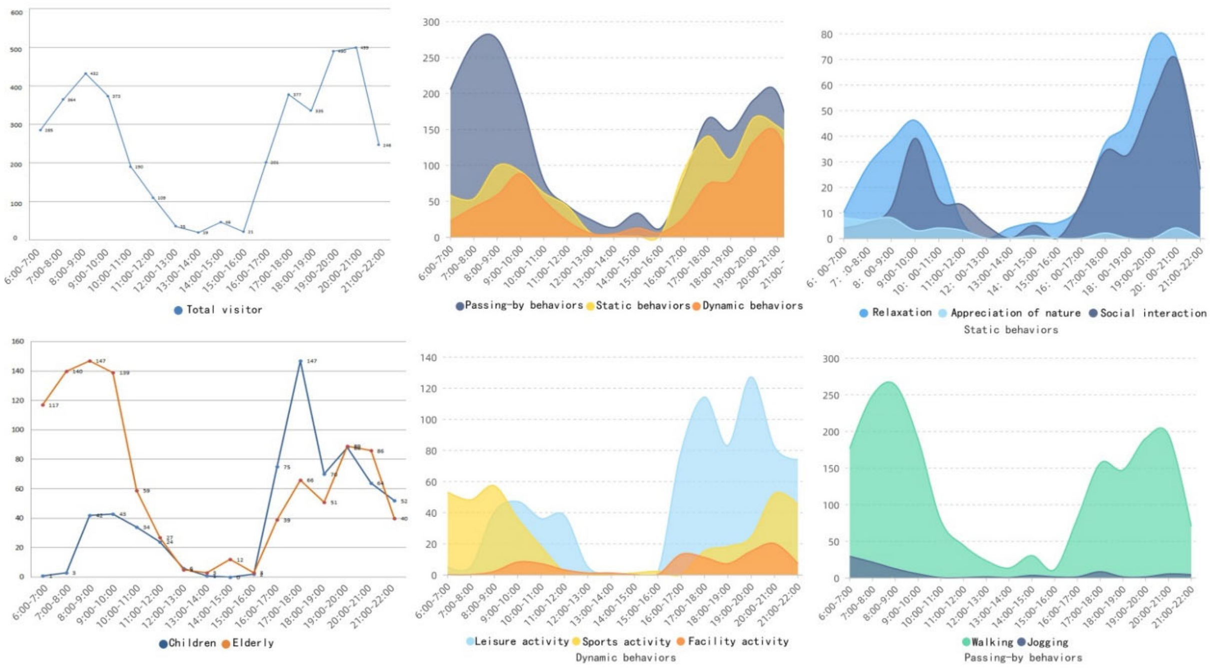


Figure 7. Time differences in each recreational behavior characteristic.

3.2.3. Spatial Characteristics of Park Visitors

Based on the kernel density estimation method, differences in the spatial distribution of park visitors are analyzed, as shown in Figure 8. Overall, visitors were present at all monitoring points. Fewer people congregated on large, rigid, paved surfaces, and most visitor activities occurred around natural landscape and small squares. Crowd size is inversely proportional to the site temperature, meaning that the hotter it is, the fewer people gather around. No. 17 and No. 19 (in Type I) are the two sites with the highest crowd densities. Regarding age groups, child visitors tended to gather in "clusters" around the planar area of the park. Younger children preferred sites No. 19 in Type I and No. 9 in Type III. No. 19 is the only playground for kids in the park, making it particularly appealing to younger children. Hence, more children gathered around the recreational facilities in small "clusters". The location with the highest concentration of children in site No. 9 is one point space next to the lawn, where some birds are artificially raised, and bird rest facilities have been constructed to give kids the opportunity to interact with natural animals. Bird-related facilities encouraged more children visitors. The behavior of park visitors of older age is more uniformly distributed than that of children, with a great fraction in all types of morning points. They favored linear pathways and mainly engaged in walking. Site No. 18 in type I attracted the greatest number of elderly visitors due to its wide linear walkways and sufficient rest areas, allowing the elderly to walk and rest.

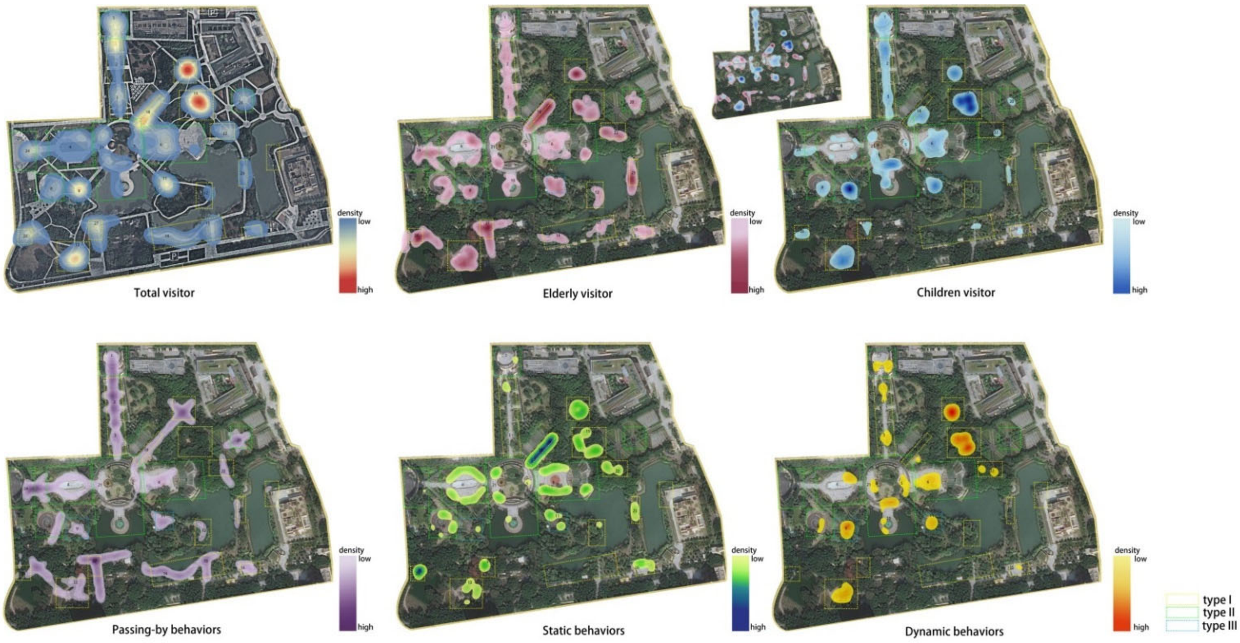


Figure 8. Spatial distribution of each behavioral feature.

The types of behaviors also show distinct spatial differences. Passing-by behaviors took up a large portion throughout the park and was linearly distributed along pathways. Static behaviors were most prevalent around the linear pathways and the periphery of the planar space with rest facilities. Sites No. 18 and No. 26 in type I exhibit a high frequency of static activity. Rest benches at site No. 18 can accommodate many people in static behaviors, while the chess table at site No. 26 is ideal for social interaction. Dynamic behaviors are more concentrated than static and passing-by behaviors and are "pointlike" on paved planar areas. Large planar space has a lower density of dynamic behavior than small planar space. Sites No. 17 and No. 19 of type I are the epicenters of the dynamic activity.

Figure 8 illustrates a relationship between the spatial distribution of visitor activities and the vegetation cover. Static behaviors were frequently observed around the edges of morning points surrounded by tall trees, while dynamic behaviors occurred at a higher density in small paved and shaded spaces. The association between vegetation shade and visitor behavior's spatial distribution was further explored (Table 4). Most daytime visitors generally prefer to perform activities under the shade of plants or structures. In nonshaded areas, there are more dynamic behaviors than static behaviors. In shaded areas, older adults preferred a sit-down or quiet activity, whereas children favored active activities. It is worth noting that older visitors were more likely to exercise in unshaded areas than in shaded areas, which may be attributed to their propensity for early morning exercise and their demand for group exercise in large open space.

3.3. Temporal Association between the Recreational Behaviors of Park Visitors and Thermal Environment

The correlation between recreational behaviors and summer temperatures fluctuated at different times. According to Table 5, there is no association between the thermal environment and activities in the morning when the temperature is in the initial phase of rising and equilibrium. As the temperature increases and reaches the highest in the late morning or afternoon, it is significantly and negatively linked with visitor numbers and non-passing-by behaviors for all ages. When the temperature exceeds 29 °C, the impact of the thermal environment on recreational activities becomes more apparent. Under high temperatures, the older group is more influenced by temperature due to their low tolerance to heat. From the morning to the afternoon, the correlation coefficient between the activity of the elderly and the temperature is −0.48 to −0.50, and the negative correlation is highly significant. In contrast, youth are less impacted by temperature, with just a negative correlation around the hot midday. As for behavior types, passing-by behaviors, such as walking and jogging, was mostly motivated by people's will and, thus, was less driven by temperature. Non-passing-by behaviors also showed a more pronounced negative correlation in the morning-to-afternoon period (static behaviors from −0.45 to −0.41, dynamic behaviors from −0.29 to −0.42).

Table 4. Percentages for places of activity of observed park visitor age groups.

Observed Place of Activity and Sun Exposure	**Percentage of People (%)**			**Observed Place of Activity and Sun Exposure**	**Percentage of People (%)**		
	Static behaviors	**Dynamic behaviors**	**Total**		**Static Behaviors**	**Dynamic Behaviors**	**Total**
All	n = 861			Children	n = 142		
Activity in shade	**34.3**	19.7	**54**		6.3	**42.9**	**49.2**
Activity in full sun	**0.2**	18.6	**18.8**		0	**23.2**	**23.2**
Activity partly in sun and partly in shade	**8.2**	18.8	**27**		0.7	**26.8**	**27.5**
Elderly	n = 232			Adult	n = 487		
Activity in shade	**44.4**	**12.9**	**57.3**		**24.6**	**31.8**	**56.4**
Activity in full sun	**0.4**	**23.7**	**24.1**		**10.9**	**11.2**	**22.1**
Activity partly in sun and partly in shade	**11.6**	**6.9**	**18.5**		**2.1**	**19.3**	**21.4**

Note: Statistically significant differences in the number of visitors who perform various behaviors in spaces with different shading conditions based on the chi-squared test. Significant differences are presented in bold ($p < 0.05$).

Table 5. Correlation analysis of parks using behavioral characteristics and temperature over different time periods.

	Early Morning	**Morning**	**Noon**	**Afternoon**	**Evening**	**Night**
All	0.091	−0.482 *	−0.368 *	−0.528 *	−0.148	0.180
Elderly	0.207	−0.489 *	−0.440 *	−0.501 *	0.158	0.195
Middle-aged adult	0.017	−0.391 *	−0.453 *	−0.316 *	−0.326 *	0.081
Young adult	0.222	−0.121	−0.360 *	−0.187 *	−0.165	0.262
Children	0.084	−0.007	−0.577 *	−0.427 *	0.222	0.205
Static behaviors	0.177	−0.457 *	−0.387 *	−0.413 *	−0.092	0.160
Dynamic behaviors	0.000	−0.292 *	−0.413 *	−0.426 *	0.054	0.013
Passing-by behaviors	0.092	−0.366 *	−0.099	−0.193	−0.182	0.142

Note: * The significance level of the mean difference is 0.05. When $p < 0.05$, there is a statistically significant difference.

We used multiple comparisons analysis to analyze the temperature preferences of different age groups and behavior types (Table 6). Table 6 shows that passing-by behaviors is distinctly more temperature-adaptive than non-passing-by behaviors. During the morning-to-afternoon period, the heat resistance of passing-by behavior is significantly higher than that of static (from 0.48 °C to 0.58 °C) and dynamic behaviors (from 0.64 °C to 1.00 °C). Regarding the two types of non-passing-by behaviors, dynamic behaviors are less heat-resistant, with the temperature demand being 0.42 °C lower than static behaviors in the afternoon. Dynamic behaviors are usually medium-to-high-intensity activities, which can lead to a quick rise in body surface temperature and make people more sensitive to summer heat. In terms of age variation, during midday when temperatures are exceptionally high, the elderly and children have a substantially lower temperature tolerance than other age groups, and their preferred temperature is approximately 1.2 °C lower than that of the young and the middle-aged. In the morning and afternoon, children could tolerate temperatures that were 0.5–0.6 °C higher than those of other age groups.

Table 6. Multiple comparisons analysis of temperature preferences for age groups and behavior types.

		Morning	Noon	Afternoon
		Mean Difference		
Elderly	Adult	−0.072	−1.192 *	−0.285
	Children	−0.603 *	−0.022	0.346
Adult	Children	−0.531 *	1.214 *	0.631 *
	Elderly	0.072	1.192 *	0.285
Children	Adult	0.531 *	−1.214 *	−0.631 *
	Elderly	0.603 *	−0.022	−0.346
Static behaviors	Dynamic behaviors	0.163	−0.208	0.421 *
	Passing-by behaviors	−0.486 *	−1.852 *	−0.584 *
Dynamic behaviors	Static behaviors	−0.163	0.208	−0.421 *
	Passing-by behaviors	−0.649 *	−1.644 *	−1.006 *
Passing-by behaviors	Static behaviors	0.486 *	1.852 *	0.584 *
	Dynamic behaviors	0.649 *	1.644 *	1.006 *

Note: * The significance level of the mean difference is 0.05. When $p < 0.05$, there is a statistically significant difference.

4. Discussion

4.1. The Moderating Effect of Park Landscape Elements on Hot Environments

Park temperature in summer was generally higher than other seasons, with an average of 31.4 °C. Paved areas are hotter than the natural landscape areas. The examination of park spatial elements and temperature revealed that both canopy density and turf coverage were found to have a notable moderating effect on the thermal environment, with canopy cover being the most important factor. The present results have been fully validated by the thermal regulating mechanisms of parks from previous studies, which suggest that crown covers of tall trees can form a green barrier with a greater shading impact than shrubs [47]. At the same level of shade, underlying surfaces have a limited effect on temperature. Lawn is a better humidifier and is cooler than paved surfaces, which is consistent with the results of Chen's study [48]. Additionally, certain factors that were considered to correlate with the thermal environment in prior research were found to be unrelated in this study. Water bodies have been demonstrated to have a cooling effect on site temperatures in various microclimate studies. However, evidence indicates that this cooling effect is insignificant in hot and humid regions [49]. The monitoring points with an average humidity of 65.8% are deemed to be hot and humid; additionally, sites adjacent to water bodies are essentially enclosed by vegetation to prevent direct contact with water. Therefore, in this study, water bodies have little impact on the thermal environment. Similarly, some scholars believe that the vertical percentage of buildings can represent the degree of shading of a single structure and that this shading effect is more effective than vegetation [50]. In this study, however, the neighboring buildings of each site are generally low-rise with marginal shading effects; thus, their moderating effect on site temperature was negligible.

4.2. Recreational Behavior Patterns in Urban Parks

The study found considerable temporal and spatial differences across age groups and behavior types. More children were observed in the late afternoon (17:00–18:00). Activities for kids were concentrated in small planar areas with play equipment and natural elements. Adams stated that children with a greater variety of equipment spent more time in playgrounds than those with monotonous equipment [51]. Contact with nature is also essential for children's motor and intellectual development. Nature serves as one of the attractions for children to stay and participate in activities [52]. It is worth mentioning that a large portion of the lawn in Hot Springs Park is inaccessible, which explains why there were few lawn activities in the observation despite its high popularity with children [53]. Elderly visitors tended to engage in physical or recreational activities in the early morning and morning (6:00–10:00) in the summer when temperatures were optimal. Seniors were spotted throughout the park, with higher concentrations along linear pathways near rest facilities. The rest facilities, such as benches, can attract seniors to sit, relax, and communicate [54,55]. Interestingly, the phenomenon of "seniors + children companionship" is frequently seen in the park, where children are playing and seniors are babysitting. This phenomenon is a topic that has received little attention in previous studies but is quite prevalent in China. Retired older adults care for their grandchildren and engage in activities with neighbors of similar age [56]. Therefore, to effectively accommodate the elderly and children, urban parks in high-density residential areas should pay more attention to the "seniors + children companionship" phenomenon.

In terms of behavior types, in summer, non-passing-by behaviors (including dynamic and static behaviors) usually occurred in the nighttime. Dynamic activities, such as frolics, exercise, and ball games, frequently happened in small planar areas. Sedentary activities such as sitting were often observed in paved spaces and along the borders of walkways adjacent to rest facilities. As the second most prevalent behavior of static activities, chess-playing occurred solely in the morning at point No. 26. This site has the only chess table in the park, which provides an excellent opportunity for this type of behavior. Social interactive activities, such as chess-playing, require pavilions, chess tables, or similar specialized facilities [32]; hence, they cannot be supported by rest benches.

4.3. Effects of Summer Heat on Park Use Patterns

During the hot summer, there is a distinct inverse linkage between park visits and temperature spatially and temporally in urban parks, indicating a "heat avoidance" tendency. In general, thermal environments are significantly connected with park behavior patterns [57]. When the temperature hits a threshold, the number of park activities decreases dramatically, which is in line with past studies on thermal environments and behavior in parks [58,59]. From 8:00 to 17:00, when the temperature is a determining factor, the elderly and children groups showed a lower heat tolerance than other age groups. Older individuals were sensitive and less tolerant of hot environments. Younger children were less tolerant of intense heat but could adapt better to higher temperatures in general hot conditions. The high-temperature tolerance for recreational behaviors in descending order is as follows: passing-by behaviors > static behaviors > dynamic behaviors. Under high summer temperatures, non-passing-by behavior typically occurred at night due to the strong influence of temperature; it was usually distributed around the peripheries of planar areas near vegetation or small point space. Dynamic behavior was more susceptible to heat. Passing-by behaviors were less affected by temperature temporally and spatially. Only extremely high temperatures could diminish this type of behavior. We mainly discussed the influence of temperature on the spatiotemporal characteristics of the public's recreational activity. However, additional factors will affect the public's visit time [60]. For instance, the mealtimes of urban residents may decrease the number of visits during midday and in the afternoon.

5. Conclusions

The urban park is an integral component of the urban green space system and plays an important role in promoting summertime activities. This study provides valuable insights into their characteristics and relationships by investigating the summertime thermal environment and recreational behaviors in an urban park. Taking a view of behavioral features and activity demands, the following recommendations are made to encourage park use, user satisfaction, and recreational behaviors under hot summer conditions.

1. Increasing canopy closure and turf coverage is the first option to alleviate the thermal environment for urban parks, which can be achieved by planting tall trees; this is critical to providing shade so as to prevent activities in direct sunlight.
2. Developing and creating playgrounds and intriguing natural areas dedicated to children can attract them. Appropriate seats and benches can be installed at the margins of large point areas or trails to support older people sit, chat, and walk.

Design some spaces where the elderly and children can play together and establish extra rest spots next to the children's play areas.

3. As more people prefer non-passing-by activities in the summer nights, it is very important to strengthen the construction of park security facilities at night, such as bright streetlights, waterside warning signs, etc. More shaded space during the day may stimulate healthy dynamic activities.

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