ISSN 2616-7433 Vol. 7, Issue 2: 9-15, DOI: 10.25236/FSST.2025.070202

A Study on Community Green Space Design Strategies Based on the Spatiotemporal Characteristics of Outdoor Activities of the Elderly

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Abstract: *In the context of rapid population aging and the severe lack of age-friendly design in outdoor physical activity spaces for the elderly in China, this study, based on behavioral observation methodology, investigates outdoor physical activities of elderly individuals in Shijingshan inner district community park during winter. The aim is to explore the spatiotemporal characteristics of outdoor physical activities among the elderly and provide a basis for redesigning community park spaces to be more age-friendly. The findings show that elderly men are more active in the afternoon, while women, influenced by their daily routines, engage in less activity in the morning. In winter, activities are more static in the morning and dynamic in the afternoon. In terms of spatial distribution, men tend to be scattered across the park, while women concentrate in sunlit areas. The spatial clustering is influenced by the venue, vegetation, and facilities. Among the types of activities, social interaction activities have the highest proportion, followed by fitness activities. Based on these findings, the paper proposes several suggestions for improvement, such as optimizing the design of activity areas, rationally configuring fitness equipment, and increasing the diversity of resting spaces to better meet the needs of elderly individuals, enhance the age-friendly functionality of community parks, and promote healthy aging.*

Keywords: *Elderly, Outdoor Physical Activity, Age-Friendly Design, Spatiotemporal Distribution Characteristics, Community Green Space*

1. Introduction

1.1 Challenges and Significance of Age-Friendly Design for Community Green Spaces in the Context of an Aging Society

China is facing a severe aging trend, with projections indicating that by 2050, the elderly population will reach 487 million, accounting for 34.9% of the total population. As the population structure shifts, promoting the health and social engagement of the elderly through environmental design has become a critical issue in addressing the challenges of an aging society [1]. The World Health Organization (WHO) recommends that elderly individuals engage in at least 150 minutes of moderate to vigorous physical activity each week, emphasizing the importance of improving community environments, particularly the design of community green spaces, to encourage outdoor activities and healthy lifestyles for the elderly [2]. However, seasonal factors, especially winter weather, often lead to a reduction in outdoor physical activities among older adults.

In this context, community green spaces play a vital role as places for elderly physical activity. The design of these spaces is crucial for the daily lives and health of the elderly. This study analyzes the spatiotemporal distribution characteristics of outdoor physical activities among elderly individuals, with a focus on winter community green spaces, and aims to explore age-friendly design strategies for these spaces. The goal is to provide theoretical support and practical guidance for improving community environmental design, ultimately promoting healthy aging among the elderly.

1.2 Outdoor Activities for the Elderly and Age-Friendly Design of Community Parks

In recent years, scholars have conducted extensive research on outdoor activities for the elderly and the age-friendly design of community parks from various perspectives. In terms of spatiotemporal characteristics, Wu Zhijian et al. (2019) [3] used GPS and GIS technologies to analyze and found significant differences in the activities of the elderly in different communities. Chen Jizhou and Zhang Jianjian (2022) [4] emphasized the importance of spatial enclosure and landscape quality in influencing

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the activity space choices of the elderly in community parks.

Regarding community parks and walking environments, multiple regression analyses have clarified the specific design needs of elderly individuals for park spaces. Guo Rong and He Yimeng (2021) [5] further confirmed the direct impact of walking environment design on the activity behaviors of the elderly. In terms of age-friendly design strategies, Shu Ping and Yin Ruozhu (2020) proposed the importance of enhancing green landscapes and optimizing activity spaces, while Li Yifei et al. (2023) [6] focused on strategies for optimizing walking spaces.

In research on influencing factors, satisfaction surveys have highlighted the importance of infrastructure, and Cui Hongjun et al. (2020) [7] revealed the influence of factors such as gender and family structure on activity choices. Although significant progress has been made in existing research, studies on the impact of seasonal and climatic changes remain insufficient. Future research should further integrate environmental factors to explore the dynamic patterns of outdoor activities among the elderly, providing more comprehensive theoretical support for the age-friendly design of community green spaces.

2. Relevant Theoretical and Methodological Foundations

2.1 Theoretical Basis

This study explores the spatiotemporal patterns of outdoor activities for the elderly based on the theories of social ecology, environmental behavior, and active aging. Social ecology theory emphasizes the dynamic interaction between human behavior and the environment, where the environment influences individual behavior, while behavior can also alter the environment [8]. Environmental behavior theory focuses on the interaction mechanisms between individuals and their surroundings. By analyzing the behavioral characteristics of the elderly in community green spaces, this theory helps uncover the spatiotemporal patterns of their physical activities [9]. Active aging theory advocates for promoting healthy aging, social interaction, and psychological well-being by designing outdoor spaces that encourage active lifestyles among the elderly [10]. Considering the natural process of aging, this approach takes into account the physiological, psychological, and social factors to help the elderly maintain good health [11].

According to the life circle theory, the activity space of the elderly can be divided into core living circles, neighborhood living circles, and urban living circles. The activity range and frequency in each circle vary, and different activity spaces should be designed according to the needs of each circle [12].

2.2 Research Design and Methods

This study adopts an interdisciplinary approach combining literature review, behavioral notation, and spatial analysis to examine the spatiotemporal distribution of elderly outdoor activities. Data collection involves onsite recording, photography, and ArcGIS platform processing, with kernel density analysis exploring spatial clustering patterns and three key influencing factors: venue, vegetation, and facilities. Observations were conducted on five days in December 2023 (December 5, 7, 12 for weekdays; December 9, 17 for weekends), avoiding adverse weather conditions. Two study sites were selected: Haite Sports Leisure Park, a rectangular park of 1.5 hectares featuring a 30-meter diameter circular hard-paved square and fitness areas, and Xishan Aoyuan Central Park, a four-leaf clover shaped park with hard-paved squares and linearly arranged fitness equipment. Both parks were chosen for their high elderly population concentration and comprehensive facilities, including squares, fitness equipment zones, and various resting areas.

3. Analysis of Spatiotemporal Characteristics of Outdoor Physical Activities for the Elderly

3.1 General Characteristics of Outdoor Physical Activities for the Elderly

3.1.1 Description of Physical Activity Frequency and Types

This study recorded a total of 357 physical activity instances across two parks, with 223 activities observed at Haite Garden and 134 at Xishan Aoyuan Central Park. Gender analysis revealed a significant disparity in participation rates, with men accounting for 63.8% (228) of total activities compared to women's 37.2% (129). This gender distribution pattern was consistent across both locations, with male

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participation reaching 60.5% in Haite Garden and 69.4% in Xishan Aoyuan. The research identified twelve distinct activity types, with the five most frequently observed being equipment-based fitness exercises (15.86%), sitting and chatting (11.25%), parent-child activities (10.68%), standing and chatting (9.31%), and brisk walking (9.14%).

Based on field observations and previous research, these activities were categorized into four major types, with social interaction activities representing the most prominent category at 35.3%, primarily involving various forms of chatting while sitting, standing, or walking. Leisure and entertainment activities constituted 22.7%, encompassing diverse activities such as singing, performing opera, playing musical instruments, board games, ground calligraphy, and dog walking. Physical fitness activities accounted for 22.1%, including group dances, ballroom dancing, linear movements like walking and jogging, Tai Chi, shuttlecock kicking, and equipment-based workouts. Quiet resting activities made up 19.9%, involving sitting, standing still, observing the surroundings, and caring for children. Additionally, these activities could be further classified by their degree of spatial movement into dynamic and static activities, or by participant numbers into group-based and individual activities.

3.1.2 General Characteristics of Physical Activity Under Subject Differences

Gender-based analysis shows that among elderly women, physical fitness activities constituted 41.9%, while social interaction, quiet resting, and leisure activities accounted for 22.5%, 16.3%, and 19.4%, respectively. The primary purpose of these activities was to improve physical health. For elderly men, activity distribution was more balanced, with no significant preference for any specific category, reflecting a trend of diversified engagement. Women showed a preference for group activities, such as brisk walking and sitting while chatting, whereas men were more inclined toward independent and static activities, such as watching board games, equipment-based fitness, and standing while chatting.

3.2 Temporal Patterns of Elderly Outdoor Activities

This study analyzed elderly activity patterns during morning and afternoon periods, revealing distinct temporal characteristics in winter conditions. Overall participation was significantly higher in the afternoon compared to morning hours, with gender-specific variations playing a notable role. Male participation showed a marked increase of 33.67% from morning to afternoon, while female participation remained relatively stable throughout the day. The temporal distribution also varied by activity type: morning hours were characterized by predominantly static activities such as social interaction and quiet resting, likely due to lower temperatures affecting physical readiness. Afternoon periods saw an increase in dynamic activities, particularly leisure and entertainment pursuits, facilitated by warmer temperatures and better sunlight conditions. Notably, social interaction and physical fitness activities maintained consistent participation levels throughout the day, suggesting these activities form stable routines in elderly daily life regardless of time period. This temporal distribution pattern provides important insights into how environmental conditions influence elderly activity choices and highlights the need for adaptive design strategies in community spaces.

3.3 Spatial Distribution Characteristics of Elderly Outdoor Activities

Using kernel density analysis via ArcGIS, this study examined the spatial clustering patterns of elderly outdoor activities, with intensity gradients visualized from green (low) to red (high). The gender-based analysis revealed distinct spatial preferences in both parks. Male activities typically formed small, scattered clusters, varying by location: in Xishan Aoyuan Central Park, men predominantly gathered in seating areas designed for board games, while in Haite Garden, they favored unshaded areas with direct sunlight. Female activities, in contrast, displayed more centralized, area-based clustering across both parks, particularly around fitness facilities and exercise zones. Notably, women in Haite Garden showed more flexible space utilization, extending their activities to both fitness equipment areas and adjacent sunny spaces. These spatial patterns reflected clear gender-specific preferences: women gravitated toward group fitness activities, creating concentrated activity zones around central squares and exercise equipment, while men maintained more dispersed distribution patterns, engaging in scattered activities such as board games and casual social interactions. This distinct clustering behavior – scattered points for men versus concentrated areas for women – remained consistent across different park areas and time periods.(Refer to Fig 1-8)

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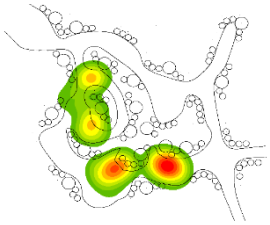

Fig.1 Physical Activity Aggregation of Males in Xishan Aoyuan

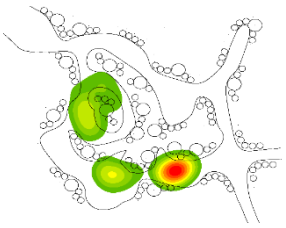

Fig..2 Physical Activity Aggregation of Females in Xishan Aoyuan

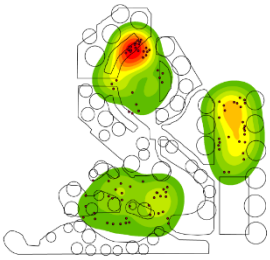

Fig.3 Physical Activity Aggregation of Males in Haite Garden

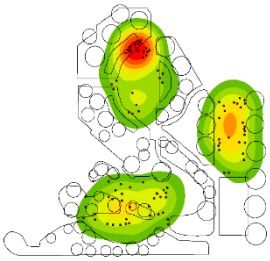

Fig.4 Physical Activity Aggregation of Females in Haite Garden

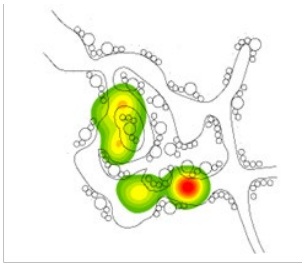

Fig.5 8:00-11:30am Gathering of Physical Activity in Xishan Aoyuan

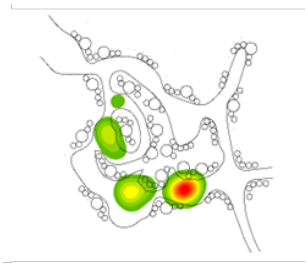

Fig.6 3:30-5:30pm Gathering of Physical Activity in Xishan Aoyuan

ISSN 2616-7433 Vol. 7, Issue 2: 9-15, DOI: 10.25236/FSST.2025.070202

Fig.7 8:00-11:30am Gathering of Physical Activity in Haite Garden

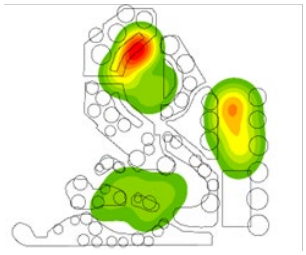

Fig.8 3:30-5:30pm Gathering of Physical Activity in Haite Garden

3.3.1 Spatial Clustering Characteristics by Time Period

This section analyzes the spatial distribution of activities in two sample parks during two peak activity periods: 8:00–11:30 AM and 3:30–5:30 PM.

During the 8:00–11:30 AM period, activities in **Xishan Aoyuan Central Park** mainly consisted of leisure and entertainment, social interaction, and physical fitness activities. These activities were primarily clustered in flat areas with tables and chairs, such as plazas, and near fitness equipment zones. In contrast, in **Haite Garden**, fewer individuals were observed in the fitness equipment zones during the morning, likely due to the lack of sunlight and lower temperatures in those areas.

In the 3:30–5:30 PM period, activities in **Haite Garden** were concentrated near fitness facilities and adjacent hard-paved plazas, with fewer people gathering in resting areas. Many elderly individuals opted to go outdoors during the warmer afternoon hours, leading to increased activity in the open plaza on the northern terrace, an area receiving abundant sunlight until sunset. Activities here predominantly included board games, chatting, and other leisure and social interactions.

3.3.2 Spatial Clustering Characteristics by Activity Type

In terms of spatial activity distribution, outdoor activities of the elderly exhibit various clustering characteristics. Leisure and entertainment activities mainly manifest in two types of clustering: functional clustering and spatial clustering. Functional clustering primarily occurs in areas with hard paving and seating arrangements, reflecting the elderly's high demand for outdoor facilities; spatial clustering mainly takes place in the open area north of the square, indicating that the elderly prefer uninterrupted open spaces for group activities.

Physical fitness activities, such as walking and exercising, typically follow a linear distribution around the square's boundaries or along pathways. Some elderly people transition to gathering areas or fitness equipment zones after exercise, forming a centripetal activity pattern with activity clusters at the core and exercise trajectories as boundaries.

Social interaction activities can be categorized into dedicated and accompanying types. Dedicated social interactions, primarily focused on chatting, concentrate in the well-lit northern open square area; accompanying social interactions, derived from other activities, are more dispersed in distribution.

Quiet resting activities mainly concentrate in seating areas and shaded spaces, with participants preferring unidirectionally arranged seats facing activity areas. Additionally, due to elderly people's need to supervise children, areas around fitness equipment have also become important resting zones.

3.4 Spatial Factors Influencing Clustering of Outdoor Physical Activities

Site characteristics, vegetation features, and facility features are the three core spatial elements

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affecting elderly outdoor activities, influencing through both physical and psychological aspects. A comparative study of Haite Garden and Xishan Aoyuan revealed:

In activity areas, spaces with diverse types, adequate sunlight, and central locations better serve elderly activities, as evidenced by the viewing platform and central stage areas in Haite Garden. Xishan Aoyuan, with its monotonous space and lack of interaction areas, struggles to attract gatherings.In fitness equipment zones, well-configured areas with green buffers creating private spaces are more popular. Haite Garden achieved high usage rates through reasonable layout, while Xishan Aoyuan's sparse facilities and poor privacy led to limited sustained use.

In resting spaces, the balance between vegetation density and sunlight exposure is crucial. Though Haite Garden's dense vegetation affects winter sunlight, its evergreen landscape still attracts visitors. Notably, seating areas around tree pits proved particularly popular, avoiding direct soil contact while providing good activity support.

4. Conclusion

This research examines elderly outdoor activity patterns through winter observations at two community parks in Shijingshan District, Beijing. The study reveals significant gender disparities: male participants (63.8%) demonstrate a preference for independent and static activities with balanced spatial distribution, while female participants (37.2%) predominantly engage in fitness activities (41.9%) and collective exercises. Temporal analysis indicates elevated participation rates in the afternoon, with male participation showing a notable increase of 33.67%. Spatial distribution patterns reveal that male activities exhibit a dispersed pattern, primarily centered around resting areas for chess and card games, while female activities form cluster formations around fitness zones.

Based on these findings, the following recommendations are proposed for community park space optimization: First, establish an integrated multi-functional activity zone system. This includes implementing platforms with elevation differences of 0.3-0.5 meters, incorporating gentle slopes not exceeding 5% gradient or age-appropriate steps, thus creating a dynamically layered activity space. The surface material should feature permeable chromatic pavement with a slip resistance coefficient $\geqslant 0.7$, enhancing thermal retention during winter. Circular walkways of 1.2-1.5 meters in width should be installed along the periphery to accommodate 2-3 people walking abreast. Second, enhance fitness equipment layout. It is recommended to maintain an 8-10 meter buffer zone between equipment areas and primary activity spaces, creating semi-private environments through 1.5-meter high evergreen shrub barriers. The equipment selection should emphasize low to moderate-intensity stretching and balance facilities, with 2-3 meter spacing between adjacent equipment and rest benches positioned at 15-20 meter intervals. Third, develop an all-season livable environment system. This encompasses installing landscape pergolas with 3-5 meter spans in sun-exposed areas, planning 50-100 square meters of gently sloped sunny lawns, and implementing a three-dimensional vegetation strategy incorporating trees, shrubs, and grass. Hard paving of 1.2-1.5 meters in width should be installed around facilities, maintaining consistency with pathway dimensions.

Future research endeavors should extend to encompass a broader spectrum of urban public spaces and seasonal variations, providing empirical evidence for enhancing age-friendly urban space design, which holds substantial practical significance in addressing the challenges of an aging population.

References

[1] Jia Zhihao. The impact of public sports space perception on health-related quality of life of elderly people in community.2023. Shandong university, MA thesis. Doi: 10.27272 /, dc nki. Gshdu. 2023.005191.
[2] Wang, D., et al., Neighbouring green space and mortality in community-dwelling elderly Hong Kong Chinese: a cohort study. BMJ Open, 2017. 7.
[3] Wu, C.J., Ni, J., and Wang, Z.Y., Community differentiation of the effects of the urban built environment and physical activity on the health of older adults. Research in Physical Education, 2023. 37(05): p. 49-61.
[4] Chen, Jizhou and Zhang, Jianjian, A study on the association between community park space and outdoor activity characteristics of the elderly. Chinese Garden, 2022. 38(04): p. 86-91.
[5] Guo Rong and He Yimeng. Optimization of Community Walking Environment Based on the Behavioral Characteristics of the Elderly: A Case Study of Haicheng Street Community in Harbin City. In 2020/2021 China Urban Planning Annual Conference and 2021 China Urban Planning Academic

ISSN 2616-7433 Vol. 7, Issue 2: 9-15, DOI: 10.25236/FSST.2025.070202

Quarter. 2021. Chengdu, Sichuan, China.
[6] Li Yifei. Research on evaluation and optimization of walking space in Capital core area based on the living circle of elderly groups.2023. Beijing university of architecture, MA thesis. Doi: 10.26943 /, dc nki. GBJZC. 2023.000113.
[7] Cui Hongjun, et al., Characteristics and Influencing Factors of Evening Leisure Activities of the Elderly. Science and Technology Herald, 2020. 38(12): p. 169-175.
[8] Stokols, D., Establishing and maintaining healthy environments. Toward a social ecology of health promotion. Am Psychol, 1992. 47(1): p. 6-22.
[9] Canter, D., The purposive evaluation of places: A facet approach. Environment and Behavior, 1983. 15(6): p. 659-698.
[10] Rowe, J.W. and R.L. Kahn, Successful Aging 2.0: Conceptual Expansions for the 21st Century. The Journals of Gerontology: Series B, 2015. 70(4): p. 593-596.
[11] King, A.C. and D.K. King, Physical activity for an aging population. Public health reviews, 2010. 32: p. 401-426.
[12] Gehl, J., "Three Types of Outdoor Activities,""Life Between Buildings," and "Outdoor Activities and the Quality of Outdoor Space": Selection from Life Between Buildings: Using Public Space, 6th edn (2011), in The City Reader. 2020, Routledge. p. 593-602.