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Analysis of the Impact of Urban Green Space System Planning on Residents' Physical and Mental Health

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Abstract: With the acceleration of urbanization in China, the population density in cities is constantly increasing, and problems such as environmental pollution and spatial congestion are becoming increasingly prominent, posing severe challenges to the physical and mental health of residents. As an important component of the urban ecosystem, the urban green space system not only undertakes ecological functions such as purifying the air and regulating the climate, but also plays a key role in alleviating residents' psychological pressure and improving their physical health. This paper systematically analyzes the specific influence mechanisms of elements such as the layout, type, scale and accessibility of urban green space system planning on the physical and mental health of residents, and proposes strategies such as optimizing the spatial layout of green Spaces, enriching the functional types of green Spaces, and improving the accessibility and service efficiency of green Spaces, providing references for the scientific and humanized development of urban green space system planning in China. Help build a modern city that is healthy and livable.

1. Introduction

Under the deep integration of globalization and urbanization, China's urban development has shifted from "incremental expansion" to "stock optimization", and residents' demands for the quality of life have upgraded from material security to health and spiritual satisfaction. However, the high-intensity development has squeezed the green space, preventing its ecological and health functions from being fully released. Moreover, factors such as air pollution, noise pollution, and lack of exercise in the urban environment are closely related to the high incidence of chronic and mental illnesses among residents. Therefore, the construction of healthy cities is facing challenges. As an ecological space with self-purification function, the planning and design of urban green space systems determine the efficiency of green space allocation and service capacity, and play a crucial role in regulating the physical and mental health of residents. Therefore, analyzing the intrinsic connection between the two, identifying the key factors of planning and proposing optimization strategies can not only enrich the theory of healthy cities but also provide scientific basis for planning practice, which is of great significance for improving the health level of residents and achieving sustainable urban development.

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2. Core elements of urban green space system planning

2.1 Spatial Layout

Spatial layout is the foundation of urban green space system planning and directly affects the accessibility and service coverage of green Spaces. A reasonable spatial layout should follow the principle of "balanced distribution and nearby service", forming a green space network system that combines "points, lines and surfaces" [1]. "Point" refers to centralized green Spaces such as urban parks and community gardens, which undertake regional service functions. The "line" refers to the greenways and green corridors laid out along roads and rivers, which undertake the functions of traffic guidance and ecological connection. The "surface" refers to large green Spaces such as forest parks and wetland parks in the suburbs of a city, which serve the functions of ecological conservation and leisure vacations.

2.2 Function Types

The diversity of green space functions directly determines its service capacity for the physical and mental health of residents. According to functional differences, urban green Spaces can be classified into four types: ecological protection type, leisure and recreation type, health promotion type and education and science popularization type. Among them, leisure and recreational green Spaces are the type of green Spaces that residents come into contact with most frequently in their daily lives, mainly meeting the needs of residents for walking, socializing, and parent-child activities, etc. Health-promoting green Spaces enhance the physical health of residents by setting up fitness trails, sports facilities and rehabilitation landscapes in a targeted manner. Ecological protection green Spaces create a healthy living environment for residents through ecological functions such as purifying the air and reducing noise.

2.3 Scale Control

The scale of green space is an important indicator for measuring the service capacity of green space, including the area scale of individual green Spaces and the overall green space ratio of the city. From the perspective of residents' health needs, the area of a single community park should not be less than 1,000 square meters; otherwise, it will be difficult to meet the daily activity needs of residents. The area of urban parks should be determined based on the scale of the population they serve. Generally, regional parks serving 100,000 to 200,000 people should have an area of no less than 10 hectares. From the perspective of the entire city, China's "Regulations on Urban Greening" stipulates that the green space ratio in urban built-up areas should not be less than 35%, among which the proportion of park green space area should be no less than 40%, to ensure the effective play of the ecological and health functions of green Spaces.

2.4 Accessibility

Accessibility refers to the convenience with which residents can reach green Spaces, usually with "a 15-minute walk to the green space" as the core standard, and it is a key factor influencing the frequency of green space usage. Accessibility is mainly influenced by traffic convenience, the density of green space distribution and the way roads are connected. Research shows that for every 10% increase in accessibility, the utilization rate of residents' green Spaces can rise by 8.5%, and health benefits will increase by 6.2% accordingly.

3. The impact mechanism of urban green space system planning on residents' physical and mental health

3.1 Impact on Residents' Physical Health

(1) Improve the urban micro-environment and reduce the risk of chronic diseases

Urban green Spaces absorb carbon dioxide and release oxygen through the photosynthesis of plants, while adsorbing particulate matter and harmful gases in the air, effectively improving air quality. Studies show that one hectare of green space can absorb 1.8 tons of carbon dioxide, release 1.2 tons of oxygen and adsorb 200 to 300 kilograms of particulate matter every day. The PM2.5 concentration in the areas around green Spaces is 15% to 25% lower than that in non-green Spaces, and the noise decibels are reduced by 5 to 10 decibels. Improvement in air quality and reduction in noise can significantly lower the risk of respiratory and cardiovascular diseases among residents [2]. In addition, green Spaces regulate the temperature and humidity of the city through transpiration, alleviate the "heat island effect", and create a comfortable living environment for residents. Data shows that in summer, the temperature around green Spaces is 3 to 5 degrees Celsius lower than that in densely built-up areas, and the relative humidity is 10% to 15% higher. This can reduce the occurrence of heatstroke, heat stroke and other diseases among residents caused by high temperatures. At the same time, it can lower the frequency of air conditioning use, reduce energy consumption and greenhouse gas emissions, and form a virtuous cycle of "health and ecology" [3].

(2) Provide sports space to enhance physical fitness

Urban green Spaces are the main places for residents' outdoor activities. Scientific green space planning can provide residents with diverse sports Spaces, encourage them to participate in sports activities such as walking, running, cycling and ball games, thereby improving their physical fitness and reducing the incidence of metabolic diseases such as obesity and diabetes. From the perspective of exercise frequency, green Spaces with high accessibility and complete facilities can significantly enhance residents' willingness to exercise. In terms of exercise effects, the natural environment in green Spaces can enhance the comfort and sustainability of exercise. The average duration of exercise for residents in green Spaces is 25% longer than that in indoor gyms, and the fatigue after exercise is reduced by 30% [4].

(3) Reduce exposure to harmful substances to ensure good health

Plants and soil in urban green Spaces have the function of degrading pollutants, which can reduce residents' exposure to harmful substances. Plants such as Platycladus orientalis and cedars can absorb heavy metals in the soil, reducing the risk of heavy metals entering the human body through groundwater or crops. Microorganisms in green soil can degrade organic matter and chemical pollutants in domestic sewage, enhancing water quality safety [5]. In addition, green Spaces, as the "green buffer zone" in cities, can reduce the impact of industrial wastewater and waste gas on residential areas and create a safe living environment for residents [6].

3.2 Impact on Residents' Mental Health

(1) Relieve psychological stress and improve emotional state

Modern urban life is fast-paced and highly competitive, making residents prone to negative emotions such as anxiety, tension and depression. From a neuroscience perspective, natural landscapes can reduce the secretion of cortisol in the human body and increase the level of serotonin. Studies show that when residents stay in green Spaces for more than 20 minutes, their cortisol levels can decrease by 12% to 15%, and their anxiety scores can drop by 20% to 25%. Viewing the green landscape for 10 minutes can increase serotonin levels by 8% to 10% and significantly alleviate depressive moods [7]. In addition, the sounds and scents in the green space can

create a peaceful and comfortable atmosphere, helping residents relax both physically and mentally and get rid of the disturbance of negative emotions.

(2) Promote social interaction and reduce feelings of loneliness

Urban green Spaces, as open public areas, provide residents with platforms for social interaction, which can promote neighborhood communication, reduce feelings of loneliness and enhance mental health levels. Scientific green space planning creates opportunities for residents to communicate by setting up facilities such as rest seats, activity squares, and children's play areas. Especially for groups like the elderly and children, they can find like-minded companions in the green Spaces and enrich their spiritual lives. Collective activities such as square dancing, Tai Chi and parent-child games in the green space can also enhance residents' sense of belonging and identity, further improving their psychological happiness.

(3) Enhance attention and improve cognitive function

The natural environment in urban green Spaces can reduce the interference of irrelevant stimuli, help residents regain their attention, improve cognitive function, and especially has a positive effect on the cognitive development of children and the elderly [8]. A study published in the Journal of Environmental Psychology in the United States in 2022 showed that children who played in green Spaces for one hour every day had 18% higher attention test scores and 15% higher memory scores than those who were active indoors. For the elderly, the natural landscapes and social activities in green Spaces can delay the decline of cognitive function and reduce the risk of developing Alzheimer's disease.

4. Optimization strategies for Urban Green Space System planning

4.1 Optimize the layout of green Spaces and enhance the balance of services

(1) In the old urban area, greenery is planted wherever possible, while in the new district, blank Spaces are left in advance.

In response to the shortage of green space resources in the old urban area, a layout approach of "greening every available space" is adopted. Idle land, building rooftops, walls and other Spaces within the area are fully explored and utilized to build small-scale green Spaces, in order to fill the gap in green space coverage in the old urban area [9]. For new urban areas, it is necessary to make "advance blank Spaces" in the planning and design stage, reserving sufficient space for green space construction. It should be clearly stipulated that the green space ratio of the new area shall not be less than 38%, and the per capita park green space area shall not be less than 16 square meters. At the same time, a "cluster layout" model is adopted to closely connect green Spaces with public facilities that residents frequently visit, such as residential areas, schools, and hospitals, ensuring that residents can conveniently access green space services.

(2) Build a "greenway network" to connect various types of green Spaces

Taking greenways as the core connection link, different types of green Spaces within the city, such as urban parks, community parks, and forest parks, are integrated to build an "interconnected" green space network system, thereby enhancing the overall service capacity and utilization efficiency of green space resources [10]. Greenway planning should follow the principle of "adapting measures to local conditions", and be laid out along linear Spaces such as rivers, roads and railways in combination with the existing terrain and spatial features of the city. At the same time, pedestrian paths, cycling paths and service stations should be set up in the greenway system to meet the diverse travel and outdoor activity needs of residents.

4.2 Enrich the functional types of green Spaces to meet diverse health needs

(1) Classify and build health-themed green Spaces

Based on the characteristics of different age groups and health needs of residents, special health-themed green Spaces should be planned and constructed in a classified manner to enhance the precision and pertinence of green space services. The key points of the specific planning are shown in Table 1.

Table 1 Key Points of Special Health-Themed Green Space Planning

Target group	Green space type	Core configuration content	Core service objective
Children's group	Child-friendly green space	Safe and non-toxic amusement facilities, nature exploration areas, and anti-slip and anti-collision ground materials	Ensure the safety of children's activities, help children get close to nature, learn natural knowledge and improve cognitive abilities
The elderly group	Health and wellness green space	Gentle slope walkways, health and wellness seats with sunshades and charging ports, traditional Chinese medicine health plant areas, and community hospital cooperative service points	Provide comfortable activity Spaces for the elderly, support physical monitoring and health management, and meet their health and wellness needs
The group of patients with sub-health and chronic diseases	Rehabilitative green space	Multi-level rehabilitation trails, tactile landscape areas for visually impaired people, meditation Spaces, and rehabilitation exercise guidance signs	Combining the theories of rehabilitation medicine, guide the group to improve their physical condition through outdoor exercise and assist in disease recovery

(2) Integrate the "five-sense experience" design to enhance the psychological healing function of green Spaces

Visually, rationally combine plants of different colors and shapes to create a landscape effect that is beautiful throughout the four seasons and enrich the visual layers of the landscape. At the auditory level, natural soundscapes such as the chirping of birds and the rustling of leaves in the wind should be retained, and artificial soundscapes like water violins and wind chimes should be appropriately configured to create a serene and comfortable acoustic environment. At the olfactory level, plants with fragrant scents such as roses, lavender and osmanthus are planted to relieve residents' anxiety with the help of their natural fragrances. At the tactile level, various ground surfaces made of different materials such as wooden platforms, pebble walkways, and lawns are set up, along with interactive facilities, to meet the tactile experience needs of residents. At the taste level, "shared vegetable gardens" are planned in community green Spaces, allowing residents to experience the joy of harvest through the process of picking and tasting, and enhancing their sense of identity and belonging to nature.

4.3 Enhance the accessibility and service efficiency of green Spaces

(1) Optimize transportation connections and shorten the time for residents to reach the green space

Strengthen the connection and adaptation between green Spaces and public transportation systems. Reasonably set up bus stops and subway entrances and exits around key green Spaces such as urban parks and large green Spaces to provide residents with convenient public transportation

options to reach the green Spaces. At the same time, optimize the road design around the green Spaces and set up isolation facilities for pedestrian lanes, bicycle lanes and motor vehicle lanes. At the same time, barrier-free passages, barrier-free restrooms and exclusive rest areas will be set up at the entrance and inside the green space, and wheelchair rental services will be provided to enhance the inclusiveness of green space services and ensure that special groups can enjoy green space resources equally.

(2) Extend the opening hours of green Spaces and enhance service flexibility

Based on the daily activity habits of residents, the opening hours of green Spaces should be reasonably adjusted and extended to enhance the flexibility and adaptability of green space services (Table 2).

Table 2 Setting of Green Space Opening Hours

Green space type	Opening hours planning	Supporting guarantee measures	Adapt to the demand scenarios
Urban parks and community gardens	From 6 a.m. to 10 p.m	Improve night lighting facilities, increase security patrol points, and equip emergency service devices	Residents exercise in the morning, relax during the day and take walks in the evening
Suburban forest park and wetland park	Summer: 6 a.m. to 9 p.m. Winter: 7 a.m. to 6 p.m	Adjust the lighting duration according to the seasons, set up seasonal exclusive safety reminder signs, and strengthen the extreme weather warning mechanism	Weekend leisure, short outdoor trips, and nature observation

4.4 Strengthen public participation and post-event management

(1) Establish a public participation mechanism to enhance the scientificity and applicability of the planning

During the initial research stage, a combination of online questionnaires and offline symposiums was adopted to widely collect residents' demands regarding the functional positioning, spatial layout, and facility configuration of green Spaces. During the scheme design stage, through forms such as planning public announcements and model displays, the content of the planning scheme is comprehensively introduced to residents, and they are invited to offer suggestions for modification and adopt them reasonably. During the later assessment stage, regular research on the usage of green Spaces should be conducted. Based on the feedback from residents regarding their usage experiences and problem suggestions, the green space planning schemes and management strategies should be adjusted in a timely manner to form a closed-loop management of "research - design - assessment - optimization".

(2) Strengthen the later management of green Spaces to ensure their continuous functioning

Establish a diversified post-management mechanism for green Spaces. At the government level, increase financial investment in green space management, formulate unified standards for green space maintenance, and conduct regular management quality assessments. At the enterprise level, through the government's purchase of services, professional landscaping enterprises are introduced to be responsible for the daily maintenance of green Spaces, and the maintenance efficiency is enhanced by leveraging professional technology and management experience. At the resident level, a "Green Space Volunteer Association" should be established to encourage residents to actively participate in the maintenance and supervision of green Spaces. At the same time, a reporting mechanism for behaviors that damage green Spaces should be set up to form a multi-party collaborative green space management pattern.

5. Conclusion

This article conducts research on the impact of urban green space system planning on the physical and mental health of residents, clarifying its core elements. Through mechanisms such as improving the urban micro-environment, providing sports Spaces, and alleviating psychological stress, it ensures residents' health from both physiological and psychological perspectives. It also proposes strategies such as optimizing spatial layout, enriching functional types, enhancing accessibility, strengthening public participation, and post-management. Provide a reference for scientific planning. In the future, we can further promote multi-disciplinary integrated research, focus on the needs of special groups, and explore a planning model that integrates "health and low carbon", so that green Spaces can better contribute to the construction of healthy and livable cities and sustainable development.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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