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## **THE INFLUENCE OF OUTDOOR SPACE SPATIAL ECOLOGICAL ENVIRONMENT FOR THE ELDERLY**

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### **Abstract**

Outdoor activities improve the physical and mental health of the elderly. Only an excellent outdoor environment can attract the elderly, increase the frequency of their activities, and improve their quality. However, there is a lack of research on urban outdoor environmental factors that influence the outdoor activities of elderly people in China. This study aims to explore outdoor environmental elements suitable for the elderly in China, explore the impact of the environment on the activities of the elderly, and better design outdoor environments for the elderly. The study selected Beishan Park in Qingdao, China, as the research location because of its outdoor environment. It explored three aspects: the physical environment, the psychological environment, and the ecological environment. A survey questionnaire was written for data collection. The data was analysed using PLS-SEM to analyse the relationship between outdoor environmental factors. The research findings indicate that the ecological environment, which fosters both the physical and psychological environments, significantly influences the outdoor activities of the elderly population. A good ecological environment can encourage the elderly to spend more time outdoors. This paper discusses the important outdoor environmental factors that affect the outdoor activities of the elderly, provides a basis for improving the outdoor environment and outdoor activities of the elderly in Chinese cities, and also provides a reference for designers and related personnel.

**Keywords:** Spatial Ecological Environment, Outdoor, Elderly, Physical, Psychological, Activities

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## **INTRODUCTION**

China's ageing population is developing rapidly and will become China's primary national condition for a long time (Bai & Lei, 2020; Han et al., 2020). According to the seventh national census in November 2020, China's population aged 60 and above accounted for 18.7% of the total population, and this proportion is still accelerating (NBSC, 2021). Moreover, with the rapid development of cities and the destruction of the ecological environment, the elderly's requirements for the outdoor environment will increase. As a vulnerable group in the city, the elderly's physical and mental health development should be considered in constructing an urban environment. In recent years, building an "age-friendly," "inclusive," and "barrier-free" city has become a high-level development goal for cities (Lui et al., 2009; Wenting et al., 2014; Yifan et al., 2020). Both the world and China are researching the happy lives of the elderly to create a harmonious city for them.

However, many outdoor environments were not designed for elders when they were originally built. China's early environmental design, particularly, ignored the needs of the elderly. Specifically, the impact of ecological factors on the elderly has been less considered, and the importance of trees and biology on the elderly's outdoor activities has not been discussed. Therefore, it is of great significance to explore the impact of urban outdoor ecological environment characteristics on the elderly's outdoor activities.

## **LITERATURE REVIEW**

### **Elderly**

The World Health Organization defines old age as people over 60 (WHO, 2002), while some Western developed countries consider 65 years old the cut-off point. People entering old age will show a decline in physical function, slow metabolism, physiological function, and other characteristics. WHO categorises the population from 60 to 74 years old as the young elderly, while those over 75 years old are solely classified as the elderly. The term "long-lived" refers to people over 90 years old.

In China, Article 2 of the Law on the Protection of the Rights and Interests of the Aged stipulates that the age threshold for the elderly is 60 years old. All citizens of the People's Republic of China who have reached the age of 60 are senior citizens. Therefore, in this study, the age limit for the elderly was 60 years and older.

### **Ecological Environment and Outdoor Activities**

A good spatial-urban ecological environment can improve the physical and mental health of elderly people who do outdoor sports. In recent years, air pollution has brought serious harm to human normal activities and life (Misni et al., 2015). As people are keen on outdoor sports, outdoor sports in an air-polluted

spatial environment will inevitably inhale more pollutants while accelerating breathing, which is detrimental to the elderly (Xu & Lyu, 2022).

In addition, thermal comfort will have an impact on the elderly's outdoor activities. In the context of global climate change, outdoor spaces that provide a pleasant thermal comfort experience for the elderly effectively improve the quality of urban life (Chen & Ng, 2012). Studies have shown that the acceptable thermal comfort range of participants can lead to significant changes in overall park visitor numbers in different seasons, while thermal adaptation characteristics affect individual differences in utilisation within different spaces in different ways. In unshaded areas of the park, visitor numbers increase as temperatures rise during the cool season and decrease during the hot season. However, as temperatures rise, both in the cool and hot seasons, the number of visitors to shady areas increases (Jing & Misni, 2024; Li et al., 2016).

There is a close relationship between the ecological environment and outdoor activities, especially for the elderly. Their physical requirements for the outdoor environment will increase. Therefore, a well-designed ecological environment significantly influences the outdoor activities of the elderly population (Jing & Misni, 2023). Under a good spatial ecological environment, physical and mental health will also improve across sports groups (Xu & Lyu, 2022).

## **METHODOLOGY**

The primary data were collected on site using mixed methods: qualitative observations and quantitative surveys.

### **Observation**

In the early stages, researchers observed the Qingdao's environmental characteristics and experiences, divided the outdoor environmental characteristics into physical environment, psychological environment, and ecological environment, and then wrote a questionnaire.

### **Questionnaire survey**

Questionnaires were distributed to the elderly in Beishan Park during the autumn in October 2022 and the spring in April 2023. This research questionnaire includes 12 basic information questions, 22 five-level quantitative questions, and 4 open-ended questions. The researchers encouraged the elderly to complete the questionnaires by themselves, but some elderly people needed help from the researchers to read aloud due to weak eyesight or a lack of patience. After the elderly answered verbally, the researchers helped record them. Some elderly people repeatedly asked questions, and the researchers were on site and provided the necessary help. The researcher collected all questionnaires upon completion. During the field research process, incomplete survey questionnaires with missing

items were deemed invalid and were not included in the scope of data collection. A total of 130 questionnaires were distributed for this survey, and 123 were recovered. The effective response rate of the questionnaire was 94.62%.

### Data analysis

All data were registered and generated using SPSS. PLS-SEM was used to analyse the validity and reliability of the data to verify the relationship between the ecological environment, physical environment, and psychological environment and the outdoor activities of the elderly.

### Study Site

This study was conducted in Beishan Park, Shinan District, Qingdao City, Shandong Province, China (Figure 1). Qingdao is a coastal city in China with a four-season temperate climate. According to the seventh Chinese census in 2020, Qingdao's elderly population has surged, with 2.04 million people aged 60 and above accounting for 20.28%.



**Figure 1:** Location of Beishan Park at Shinan District, Qingdao City, Shandong Province, China (36.07201°N Latitude, 120.41092°E Longitude and an average elevation 27m), surrounded by high density of residential blocks/areas  
*Source: Googlemaps (2024)*

Beishan Park boasts numerous old residential areas, the majority of which date back to the 1980s. Many senior citizens gather in the park for outdoor activities. The aging rate in the residential areas around Beishan Park is 21%; the current aging rate in China is 18.7%, which is much higher than the average. Beishan Park was chosen for this study because it is home to many elderly people.



**Figure 2:** Spatial distribution of Beishan Park  
*Source: Authors (2024)*

Qingdao Beishan Park is one of the parks formed in the early days of the founding of the People's Republic of China (Figure 2). The government invested in the park in 1990 and continued to renovate in 2001. The park area is about 70,000 square meters. Planting with trees such as Black pine, Cherry blossoms, Albizia julibrissin, Magnolia and other varieties. In March 2002, 18,100 total of trees were planted. In 2004 and 2005, 1,800 and 400 red maples were planted, respectively. The entire park's natural appearance and ecological environment have undergone major changes. Beisha Park has prominent spatial characteristics. The space includes a sports space, a social dancing space, an exercise space, etc. According to the definition of terraces and trees, tall trees naturally form a top interface, shrubs form a vertical interface, and the elderly automatically form a chorus area, and a Tai Chi space. Beishan Forest Park has clear ecological functions and a pleasant environment. Many elderly people are active here (Jing & Misni, 2024).

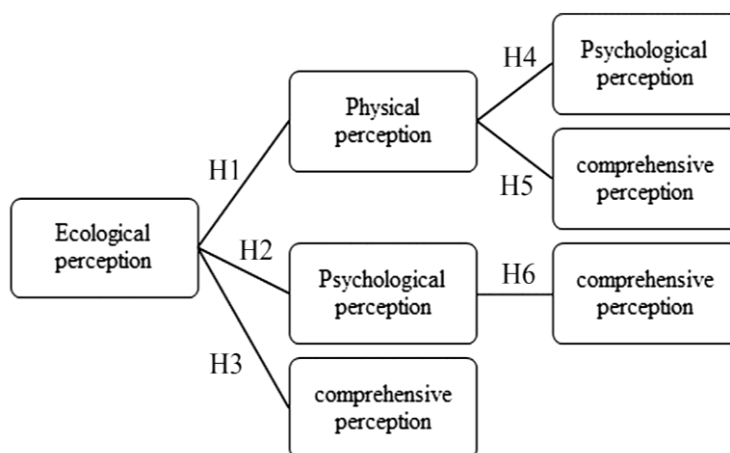
### **PLS-SEM ANALYSIS**

Beishan Park is a forest park with an excellent ecological environment. This study first conducted behavioural observation and monitoring of the elderly in the park and found that every part of the park was well-utilised at various times. Different seniors will participate in activities at different times. The literature divides the relevant landscape perception elements of outdoor environmental quality into three parts: ecological perception, physical perception, and psychological perception.

The term "ecological perception" primarily describes how elements of the ecological environment, such as trees, water features, biological elements,

and ecological amenities, affect the outside environment of the elderly. Physical perception primarily describes how specific physical amenities, such as benches, restrooms, barrier-free areas, landscape features, etc., affect the senior population's outdoor environment. Psychological perception primarily describes the experiences that senior citizens have in the outdoors as a result of outdoor activities, including psychological safety, communication, happiness, depression, and intergenerational integration. The following presumptions are combined with the observation analysis and research purpose (Figure 3):

- Hyphothesis 1. Physical perception was influenced by ecological perception quality.
- Hyphothesis 2. Psychological perception was influenced by the quality of ecological perception.
- Hyphothesis 3. Comprehensive perception was influenced by the quality of ecological perception.
- Hyphothesis 4. Mental perception was influenced by physical perception.
- Hyphothesis 5. Synthetic perception was influenced by the quality of physical perception.
- Hyphothesis 6. Synthetic perception was influenced by mental perception quality.



**Figure 3: Hypotheses and Research Model**  
*Source: Authors (2024)*

**Measurement Model for Evaluation (ECONO)**

The primary focus of this study was how the physical, ecological, and psychological environments affect older people's outdoor activities. Figure 4 depicts the study's organisational framework. Trees, ecological infrastructure,

water systems, etc., are the primary components of the ecological environment. Ecological factors were assigned the code ECO, and the corresponding sub-project codes were ECO1–ECO7. The outside amenities and architectural aspects were where the physical environment mostly begins. The associated subproject codes were PHY1–PHY7 in order, while the physical environment was designated as PHY. Emotional exchange and generational relationships among the elderly are fundamental to psychological experience. The associated subproject codes were PSY1–PSY7, and the psychological experience element was assigned the code PSY. SUM was the code assigned to the complete perception problem.

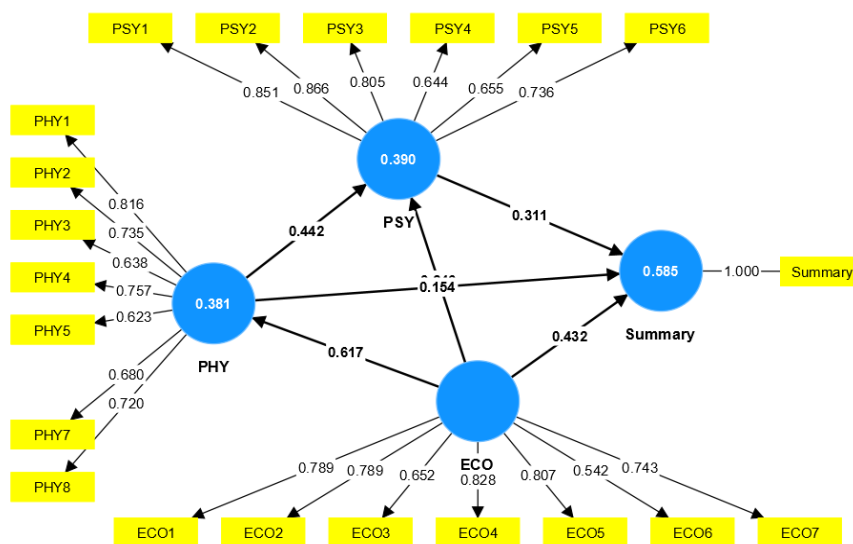


Figure 4: Outer model assessment  
Source: Authors (2024)

The measurement model was assessed using confirmatory factor analysis (CFA). Convergence validity was assessed using factor loading, mean-variance extraction (AVE), and composite reliability (CR). Every item had loads larger than 0.5, every AVE value was more significant than 0.5, and every CR value was greater than 0.7, as indicated in Table 1. Furthermore, a CR value significantly higher than 0.7 suggests the reliability of every construct employed in this investigation (Hair, Risher et al., 2019; Hair, Sarstedt et al., 2019).

**Table 1:** Result of Measurement Model

Items	Loading	Cronbach's alpha	Composite reliability (CR)	Average variance extracted (AVE)
ECO1	0.816			
ECO2	0.821			
ECO3	0.509			
ECO4	0.828			
ECO5	0.658	0.865	0.898	0.561
ECO6	0.807			
ECO7	0.748			
PHY1	0.734			
PHY2	0.639	0.84	0.79	0.511
PHY3	0.771			
PHY4	0.693			
PHY5	0.793			
PHY6	0.703			
PHY7	0.660			
PHY8	0.857			
PSY1	0.647			
PSY2	0.851			
PSY3	0.698	0.872	0.904	0.613
PSY4	0.800			
PSY5	0.822			
PSY6	0.816			
SUM	1			

Source: Authors (2024)

**Table 2:** Discriminant Validity of Constructs

	ECO	PHY	PSY	SUM
ECO	<b>0.899</b>			
PHY	0.899	<b>0.881</b>		
PSY	0.894	0.881	<b>0.885</b>	
SUM	0.891	0.892	0.885	<b>0.885</b>

Source: Authors (2024)

The criterion developed by Franke and Sarstedt (2019) evaluated the discriminant validity. Table 2 demonstrates that discriminant validity was attained since all of the square roots of the AVE, as indicated by the bolded values on the diagonals, were more significant than the corresponding row and column values.



**Evaluation of structural model**

Table 3 displays the outcomes of the hypothesis testing. H1 was supported by the results, which indicated a significant association ( $\beta = 0.782, p < 0.05$ ) between ecological and physical perceptions. H2 was supported by a substantial correlation ( $\beta = 0.443, p < 0.05$ ) between ecological and psychological perception. H3 was confirmed by a significant association ( $\beta = 0.334, p < 0.05$ ) between comprehensive and ecological perception. Simultaneously, a substantial positive correlation was found between the fit degree of physical perception ( $\beta = 0.439, p < 0.05$ ) and psychological perception, supporting H4. Comprehensive perception and the fit degree of physical perception ( $\beta = 0.305, p < 0.05$ ) showed a positive correlation, supporting H5. Furthermore, the findings indicated a substantial association ( $\beta = 0.335, p < 0.05$ ) between complete perception and psychological perception.

According to the model, the ecological environment affects the physical environment and psychological environment, and the ecological environment plays a vital role in the comprehensive experience of the elderly's activities.

**Table 3: Results of Hypotheses Testing**

	<b>Std beta</b>	<b>Std error</b>	<b>T values</b>	<b>P values</b>	
ECO -> PHY	0.782	0.031	25.041	0	supported
ECO -> PSY	0.443	0.074	6.027	0	supported
ECO -> SUM	0.334	0.074	4.518	0	supported
PHY -> PSY	0.439	0.078	5.623	0	supported
PHY -> SUM	0.305	0.072	4.209	0	supported
PSY -> SUM	0.336	0.076	4.392	0	supported
Note: Significant at $p < 0.01$					

*Source: Authors (2024)*

**DISCUSSION**

The ecological environment has an important impact on the elderly's outdoor activities, according to the PLS-SEM model. The impact on the ecological environment is mainly reflected in air quality purification, thermal comfort, biodiversity, and other factors. Trees are the most important factor in the park's ecological environment. They can purify the air, improve air quality, and keep the elderly's respiratory system healthy. Trees can also provide shade, lowering outdoor temperatures and improving comfort during hot weather. Parks provide a comfortable shade environment that is very helpful to the elderly. At the same time, more trees attract more creatures, making the biological species here richer and more diverse, and encouraging more elderly people to participate in the interaction with the natural environment.

Beishan Park is built in an old residential area. There are many trees in the park, and the sunlight creates a dappled effect through the shade of the trees. The air is fresh, the climate is comfortable, and there is a lot of biology. This is an excellent place for seniors to visit. The elderly prefer the natural environment; this is a forest park closer to nature. Here, they play chess, Tai Chi, and square dance, care for their grandchildren, lead colourful retirement lives, and enjoy family happiness. The ecological and environmental factors, as well as the characteristics of Qingdao Beishan Park are discussed and analysed below.

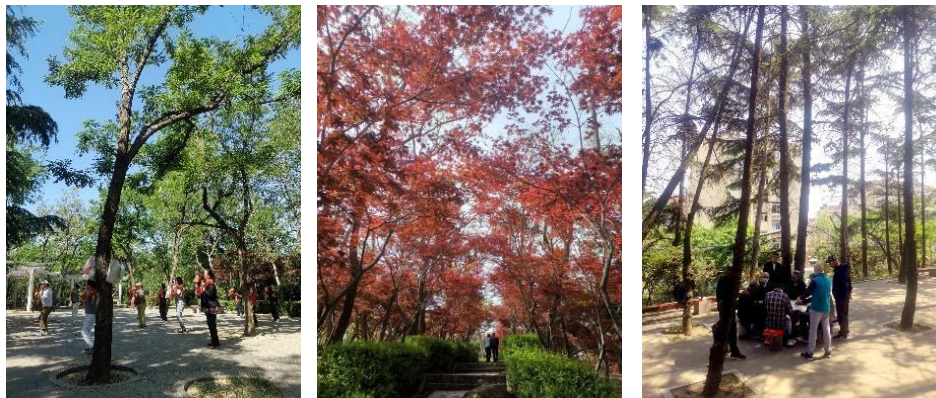
### Main Arbors

Beishan Park is particularly rich in plants, which carry ecological, structural, and visual functions. By 2005, the park had 33,400 plants from 50 species of trees and shrubs. The ratio of Arbors trees and shrubs is 1:3, and the ratio of evergreen and deciduous trees is 1:1.05. Many trees create an excellent ecological space for the elderly. The whole park is beautiful, with birds singing, as well as flowers and sunshine shuttling in the shade.

**Table 4:** The Main Arbors Trees in The Beishan Park

No.	Common name	Scientific name	Nos.	Height (m)	DBH (cm)	Canopy width (m)	Seasonal type
1	Locust tree	<i>Styphnolobium japonicum</i> 'Pendula	600	10-20	15-25	5.0-8.0	Deciduous
2	Acer palmatum	<i>Acer palmatum</i> Thunb. in Murray	400	5	5-10	2.5-3.0	Deciduous
3	Paulownia	<i>Paulownia fortunei</i> (Seem.) Hemsl.	120	15-20	50	8-12	Deciduous
4	Oriental plane	<i>Platanus orientalis</i> L.	100	12-20	40-60	8-12	Deciduous
5	Hackberry	<i>Celtis sinensis</i> Pers	200	9	15-20	3-5	Deciduous
6	Pine tree	<i>Pinus</i> Linn	1000	15-20	30-50	6-12	Evergreen
7	Cypress	<i>Cupressus funebris</i> Endl.	200	10-20	20-40	3-5	Evergreen
8	Oriental cherry	<i>Prunus</i> subg. <i>Cerasus</i> sp.	20	5-10	4-16	3-6	Deciduous
9	Magnolia	<i>Yulania denudata</i>	10	8-15	10-20	4-6	Deciduous
10	Ash tree	<i>Fraxinus chinensis</i>	60	6-12	8-20	4-6	Deciduous
11	Albizzia julibrissin	<i>Albizzia julibrissin</i> Durazz	300	6-10	12-30	4-8	Deciduous
<b>Total/Mean</b>			<b>3010</b>	<b>18</b>	<b>35</b>	<b>10</b>	<b>Deciduous</b>

Source: Authors (2024)



**Figure 5:** *Styphnolobium japonicum* 'Pendula' (left), *Acer palmatum* Thunb. in Murray (middle), and *Pinus Linn* (right)  
Source: Authors (2024)

Due to the large number of trees in Beishan Park, the specific number of each tree was not recorded in this table. However, according to "Qingdao Landscape Annals," recorded in March 2002, the second phase of the greening project started. Dongshan South Slope construction covers an area of 3000 square metres of garden. Landscape woodlands such as *Albizia julibrissin* Durazz., *Yulania denudata* (Desr.) D. L. Fu, and *Acer palmatum* Thunb. in Murray were built, and 18,100 trees were planted. In 2003, Beishan Park planted a red maple forest. In 2004 and 2005, 1,800 and 400 plants of red maple were added. In 2005, the park had 33,400 plants of 50 species of trees and shrubs, and more than 6,400 climbing plants.

The pine trees in Beishan Park are tall and large. Under the big branches are cool and shaded spaces, which provide a roof of leaves for the elderly when the weather is hot. Both the "potential refuge theory" and the "savanna hypothesis" suggest that humans are attracted to tree canopies because they are optimal for survival (Orians, 2022). Later studies have confirmed this preference (Lohr & Pearson-Mims, 2006). For the elderly, shade trees can improve outdoor comfort, reduce glare, and serve as landmarks in outdoor areas (Zeisel, 2007).

The elderly here especially enjoy playing tai chi, or sword dance, under the trees. The tall locust trees and pine trees interlace together to provide a green environment for the elderly, attracting many elderly people and children to play under the trees. Beishan Park boasts a multitude of red maple trees, while the purple hue of the surrounding mountains creates a striking contrast. Others, such as cherry blossoms and magnolia flowers, adjust the colour interest for the park environment and provide ornamental functions for the elderly.

### Main shrubs

The shrubs in Beishan Park are mainly used to demarcate areas and boundaries, but some shrubs have no ornamental function. The *Buxus sinica* var. *parvifolia* M. Cheng was artificially pruned to form the region's boundary. The volume of *Photinia serratifolia* (Desf.) Kalkman is large, produced the white flowers in May. Similarly, *Lagerstroemia indica* L., and *Forsythia suspensa* were in bloom season and had bright colours that added aesthetic value to the green space. These shrubs play a good role in the transition spaces between trees and ground cover, and the plant space is well-proportioned and comfortable with high and low levels.

**Table 5:** The Main Shrubs Trees in The Beishan Park

No.	Common Name	Scientific name	Areas	Height (m)	Canopy Shape	Canopy Width (m)	Seasonal Type
1	Boxwood microphylla	<i>Buxus sinica</i> var. <i>parvifolia</i> M. Cheng	600	2-5	Rectangle	2.5-3	Evergreen
2	Photinia	<i>Photinia serratifolia</i> (Desf.) Kalkman	30	1-3	Round	2-3	Evergreen
3	Hydrangea	<i>Hydrangea macrophylla</i> (Thunb.) Ser.	36	0.5-5	Round	1-1.5	Deciduous
4	Fructus forsythiae	<i>Forsythia suspensa</i>	24	2-3	Dendritic	1-1.5	Deciduous
5	Rose	<i>Rosa centifolia</i> L.	70	1-2	Cluster	1-1.5	Deciduous
6	Pearl plum	<i>Sorbaria sorbifolia</i> (L.) A. Braun	400	3-5	Rectangle	1-1.5	Evergreen

Source: Authors (2024)



**Figure 6:** *Buxus sinica* var. *parvifolia* M. Cheng (left), *Photinia serratifolia* (Desf.) Kalkman (middle), and *Forsythia suspensa* (right)

Source: Authors (2024)

**Main Groundcovers**

Beishan Park is especially rich in plants, with a green coverage rate of 85.56%. The entire park’s green space is comfortable. Throughout the day, the park is a mix of sun and shade, with no exposure to the sun. During the survey questionnaire process, it was also found that the number of elderly engaged in activities in the whole park was similar at all times of the day, and the elderly continued to participate in activities during the day. However, after six o'clock in the evening, the number of elderly people significantly decreased, possibly due to the abundance of trees, inadequate lighting, and other factors that made the elderly feel unsafe.

**Table 5:** The Main Groundcovers Trees in Beishan Park

No.	Common Name	Scientific Name	Height (cm)	Area (m <sup>2</sup> )	Seasonal Type
1	Ryegrass	<i>Lolium perenne L.</i>	30-90	940	Evergreen
2	Mint	<i>Mentha haplocalyx Briq.</i>	10-30	120	Evergreen
3	Bluegrass	<i>Poa Linn</i>	30-100	50	Evergreen
4	Iris	<i>Iris tectorum Maxim</i>	30-60	200	Deciduous
5	Magritte	<i>Bellis perennis L.</i>	10-20	250	Deciduous
6	Dandelion	<i>Taraxacum mongolicum</i>	15-50	80	Deciduous

*Source: Authors (2024)*



**Figure 7:** Activities of the elderly at different times (8:00am-left and 10:00am-right)

*Source: Authors (2024)*

The ecological environment of Beishan Park was perfect, and the utilisation of space had been excellent at various periods. The above figure shows the use of different spaces at different periods. Many soft landscapes make the whole park full of nature.

## **CONCLUSION**

A questionnaire survey was conducted in Beishan Park. Generally speaking, the ecological environment here is perfect, with many trees and fresh air. When the weather is hot, the temperature in Beishan Park will be lower than in the surrounding area, which is suitable for the elderly. The ecology here is sound, with more plant and animal species than the surrounding environment. Elders like to come here to interact with various creatures, appreciate flowers and plants, and listen to birdsong. A healthy ecological environment will benefit both the physical environment and the psychological experience. Whether it is sedentary, moderate, or vigorous activity, elders are willing to participate in different activities based on their needs.

For the elderly, a good outdoor environment can meet their activity needs, especially a good ecological environment with suitable temperature and comfort, allowing them to stay outdoors longer. According to the survey results, Beishan Forest Park has obvious spatial characteristics, with green trees and a higher number of activities for the elderly than other surrounding areas. The elderly strongly recognise the ecological environment's impact on outdoor activities. They hope to increase seating facilities under the shade of trees. The scope of activities of the elderly is also related to the location and facilities of the space to a certain extent. Safety, convenience, comfort, diversity, and ecology are the embodiments of a high-quality outdoor environment. In general, the outdoor environment has a direct impact on the elderly's outdoor activities, especially a good ecological environment that can improve the time and quality of activities.

In conclusion, this study explored the influence of environmental characteristics on exercise preferences in the elderly. Despite focusing on the elderly population in Qingdao City, this study holds significant relevance for China and other East Asian countries or regions. Understanding the impact of various environmental factors and the activity preferences of the elderly can help designers produce a better design for outdoor environments suitable for them.

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## **ETHICAL STATEMENT**

The authors declare no conflicts of interest regarding the paper's publication. The participants of this study were agreed to have their scores published in this paper.

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