

Space-time Evolution and Causes of Commercial Sports Facilities in the Main Urban Area of Xi 'an City

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ABSTRACT

The construction of urban commercial sports facilities plays an important role in improving the national fitness system. This article takes commercial sports facilities in Xi'an as the research object, and selects POI data from 2013, 2016, 2019, and 2022 to explore their spatiotemporal evolution and causes. Research has found that the spatial distribution of commercial sports facilities in Xi'an is a multi-core agglomeration, with expansion direction similar to the urban development direction; Population, economy, transportation, and spatial location factors all have a significant impact on the spatial pattern of commercial sports facilities in Xi'an. Among them, road network density has the greatest impact, followed by population density, nighttime light index, and street distance from the city center. The density of public transportation and subway stations, per capita income, and distance from universities have a relatively small impact.

KEYWORDS

Xi 'an City; Commercial Sports Facilities; Spatial and Temporal Pattern; Influencing Factors.

1. INTRODUCTION

The reasonable layout of urban sports facilities helps to build a national fitness system covering the whole society, enhance residents' willingness to exercise, and then effectively promote the national fitness life. The combination of sports phenomena and geographical studies has a long history. With comprehensive reference to the research content of sports facilities, sports space, sports behavior and other directions, this paper sorted out the research of scholars using geographical theories and methods in the field of sports mainly includes the following three points: ①Spatial pattern analysis of sports facilities. Such as the spatial layout of sports facilities and its influencing factors, accessibility and fairness. ②Sports behavior research. Such as the characteristics, rules and differences of residents' leisure sports behavior in time and space, the relationship between built environment and residents' physical activity. ③Sports needs of different groups. The academic circles pay more attention to the sports needs of special groups such as teenagers and the elderly, and put forward reasonable suggestions for improving the layout of urban sports facilities.

Taking the commercial sports facilities in Xi 'an as the research object, this paper discusses the spatio-temporal evolution pattern and influencing factors of commercial sports facilities in the city, in order to provide reference and basis for the layout of sports industry in Xi 'an.

2. OVERVIEW OF THE STUDY AREA

This paper studies 57 streets in six districts of Xi 'an (Xincheng District, Beilin District, Lianhu District, Yanta District, Weiyang District, Baqiao District), and Guodu Street and Wequ Street in Chang 'an District, with a total of 59 streets, which are basically the core area of the spatial structure of the development of Xi 'an sports industry, and also the densely populated and economically concentrated area of Xi 'an. Therefore, it is typical and representative to choose the above region as the research area.

3. DATA AND METHODS

3.1. Data Sources

POI data can directly reflect the spatial distribution pattern of the research object, and POI data based on different time periods can reflect the temporal evolution characteristics of the research object. Based on relevant documents and previous studies, this paper defines commercial sports facilities as venues, buildings and related fixed ancillary equipment that are used for sports competitions, training and public leisure and fitness for profit purposes and meet their use requirements. It mainly includes ball sports venues, swimming pools, gyms, yoga studios, martial arts fighting venues, etc.

This study obtained the POI data of Xi 'an in 2013, 2016, 2019 and 2022 respectively through Autonavi Open platform. At the same time, it also obtained the data of Xi 'an bus station, subway station, residential district and university through Autonavi open platform. Other basic data include: The road network and administrative boundary data of Xi 'an city obtained from Openstreet platform, the second-hand housing price of Xi 'an City obtained from Anjuke website, the per capita income level obtained from 58.com, the night light data obtained from the official website of the National Oceanic and Atmospheric Administration of the United States, and the seventh census data of Xi 'an City obtained from the Xi 'an Bureau of Statistics. All dates are July 2022.

3.2. Research Method

(1)Nearest Neighbour Analysis.The nearest neighbor analysis can reveal the spatial distribution level by comparing the actual nearest neighbor distance and the theoretical nearest neighbor distance between each element. The spatial distribution state of sample points can be judged by R value: when $R > 1$, the spatial points are evenly distributed; When $R = 1$, the space points are randomly distributed. When $0 < R < 1$, the distribution is clustered, and when $R = 0$, the distribution is completely clustered.

(2)Kernel Density.Kernel density estimation is widely used in spatial analysis of point and line elements. This method gives different weights to the sample points through kernel function, so as to obtain a smoother density map. Using kernel density analysis, the spatial distribution characteristics of commercial sports facilities in Xi 'an and their diffusion distance attenuation law can be directly reflected.

(3)Standard Deviation Ellipse.Standard deviation ellipse is a common spatial statistical method to describe the distribution characteristics of geographical elements. In this study, the center of gravity of the ellipse represents the relative position of the spatial distribution of commercial sports facilities. Angle represents the main trend direction of the spatial distribution of commercial sports facilities. The main axis is the dispersion degree of commercial sports facilities in the main trend direction. The short axis is the degree of dispersion of commercial sports facilities in the direction of sub-trend.

(4)Geodetectors. Geodetectors are a group of statistical methods for detecting spatial differentiation and revealing the driving forces behind it. Because it is more convenient to use than traditional statistical methods, it is widely used in the study of the influence mechanism of social economic factors and natural environmental factors. This paper mainly uses factor detection in geographic

detector. The significance of factor detection is to detect the extent to which a factor X explains the spatial differentiation of the attribute Y. This paper mainly explores whether population, economy, traffic, spatial location and other factors have a significant spatial impact on the change of the density of commercial sports facilities in Xi 'an City.

4. SPATIAL AND TEMPORAL DISTRIBUTION CHARACTERISTICS OF COMMERCIAL SPORTS FACILITIES IN XI'AN CITY

4.1. The Trend of Commercial Sports Facilities Gathering in Xi 'an is Obvious

In ArcGIS, the nearest neighbor distance analysis was used to analyze the data of commercial sports facilities in four years respectively to study their overall distribution characteristics. The nearest neighbor index was 0.650 in 2013, 0.514 in 2016, 0.472 in 2019, and 0.416 in 2022. According to the nearest neighbor index, it can be preliminarily determined that the commercial sports facilities in Xi 'an present agglomeration characteristics in the four periods ($R < 1$). At the same time, in the analysis, the decrease of average distance, expected distance and nearest neighbor index also indicates that the average density of commercial sports facilities in Xi 'an has increased year by year, and the degree of agglomeration has continued to strengthen.

4.2. The Distribution Direction of Commercial Sports Facilities in Xi 'an is Consistent with the Direction of Urban Development

According to Figure 1 and the analysis data, the center of gravity of commercial sports facilities in Xi 'an has not shifted much in general from 2013 to 2022. However, the area of standard deviation ellipse is increasing, which indicates that the distribution range of commercial sports facilities in Xi 'an is expanding continuously. The deviation between X axis and Y wheelbase of the standard deviation ellipse increased year by year, indicating that the distribution range of commercial sports facilities in Xi 'an City expanded year by year in the direction of main trend and sub-trend. The rotation Angle of the ellipse varies between 25.817° and 45.646° , indicating that its development direction is "northeast-southwest", which is basically consistent with the development direction of Xi 'an city, and also confirms that the direction distribution of commercial sports facilities in Xi 'an is directly related to urban development.

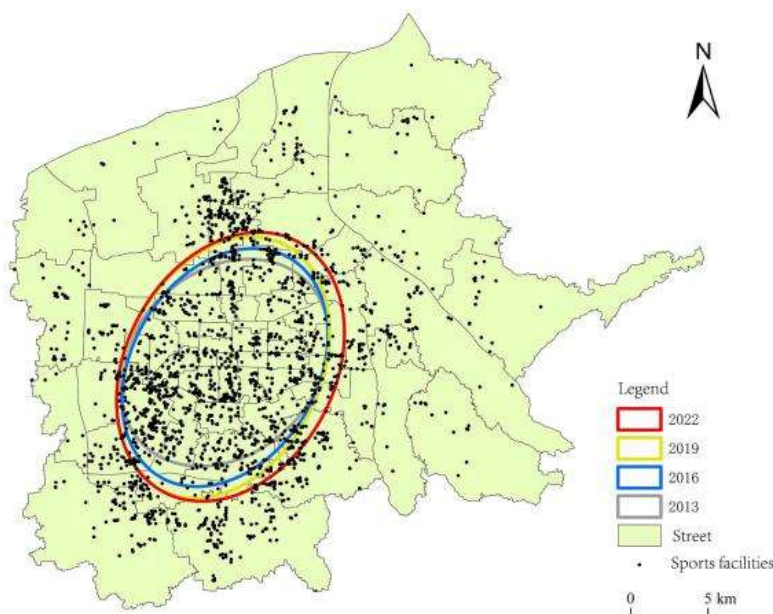


Figure 1. Xi 'an commercial sports facilities distribution standard deviation ellipse

4.3. The Spatial Distribution of Commercial Sports Facilities in Xi 'an Presents Multi-core Agglomeration

In order to more intuitively reflect the spatial characteristics of commercial sports facilities in Xi 'an city, a kernel density analysis was carried out on the cross-section data of four years (Fig.2). In general, from 2013 to 2022, the distribution of kernel density of commercial sports facilities in Xi 'an city has a large difference, and the kernel density value has increased significantly.

Specifically, in 2013 (Fig.2a), commercial sports facilities in Xi 'an had multi-regional agglomeration, but the kernel density value was generally low, showing a group-like distribution. In 2016 (Fig.2b), commercial sports facilities in Xi 'an began to form a high-density cluster core, and with the northward relocation of the administrative center of Xi 'an and the improvement of nearby commercial planning, the kernel density value expanded to the north of the city. In 2019 (Fig.2c), the kernel density value of the commercial sports facilities cluster area in Xi 'an continued to increase, and high-density areas in the urban area have been developed in consecutive plots, extending in two directions: north and south. In 2022 (Fig.2d), the proliferation of commercial sports facilities is more obvious. At present, the high-tech business district based on Zhangba Street and the Xiaozhai Business district on Chang 'an Road have formed adjacent agglomeration cores; After a long period of development, the administrative center of Zhangjiapu Street has also formed a gathering core in the north of the city. So far, the commercial sports facilities in Xi 'an have shown the spatial distribution characteristics of multi-core agglomeration.

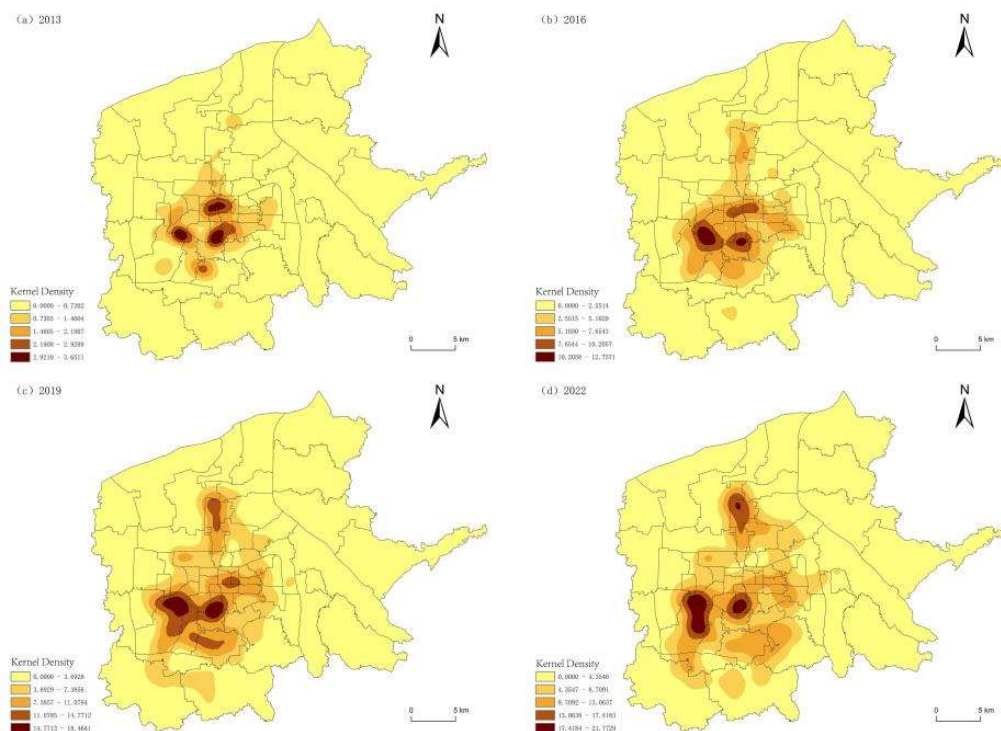


Figure 2. Kernel density map of spatial distribution of commercial sports facilities

5. INFLUENCING FACTORS OF SPATIAL DISTRIBUTION OF COMMERCIAL SPORTS FACILITIES IN XI 'AN CITY

5.1. Index Construction of Influencing Factors

Based on the research of relevant scholars, this paper comprehensively considers the availability and scientificity of indicators, and selects eight factors, including night lighting index, per capita income level, population density, road network density, bus station density, downtown distance, subway

distance and university distance, as independent variables (Table 1), and the density of commercial sports facilities within the street range as dependent variables. Based on the data of 2022, the influence factors of the spatial distribution of commercial sports facilities in Xi 'an were studied by using geographic detectors.

Table 1. factors Influencing the spatial layout of commercial sports facilities

Primary Index	Secondary Index	Explanation
Traffic Factor	Road network density (X_1)	Road density within the street
	Bus station density (X_2)	Density of bus stops in the street
	Distance to the nearest subway (X_3)	The street is a distance from the nearest subway station
Steric Factor	Distance from city center (X_4)	Distance between streets and city center
	Distance to the nearest university (X_5)	The distance between the street and the nearest university
Economic Factors	Night Light (X_6)	Average street light index at night
	Per capita income (X_7)	Subdistrict per capita income level
Demographic Factor	Population density (X_8)	Street resident population density

5.2. Factor Detection Result

As can be seen from Table 2, firstly, road network density, population density, night light index and distance from the city center are the most important factors affecting the spatial distribution of commercial sports facilities in Xi 'an. Secondly, the density of bus stations, distance of subway stations, distance of universities and per capita income also have a certain impact on the spatial distribution of commercial sports facilities in Xi 'an.

Table 2. Geo-detector result

Primary Index	Secondary Index	q Value
Traffic Factor	Road network density (X_1)	0.448 ^{***}
	Bus station density (X_2)	0.260 ^{**}
	Distance to the nearest subway (X_3)	0.214 ^{**}
Steric Factor	Distance from city center (X_4)	0.363 ^{***}
	Distance to the nearest university (X_5)	0.167 [*]
Economic Factors	Night Light (X_6)	0.375 ^{***}
	Per capita income (X_7)	0.154 [*]
Demographic Factor	Population density (X_8)	0.431 ^{***}

Note: *, **, *** represent confidence levels of 0.1, 0.05 and 0.01 respectively.

Road network density has a strong explanatory power to the spatial distribution of commercial sports facilities in Xi 'an, and its q value is 0.448, which is the highest value among all the influencing factors. The distance between the street and the subway station and the density of the bus stop can not be underestimated. The distance between the street and the city center has a significant effect on

the distribution of commercial sports facilities, and the explanatory power is 0.363. For example, Zhangba Street and Chang 'an Road are adjacent to the city center. At the same time, the distance between the street and the university also has a certain impact on the spatial distribution of commercial sports facilities. In addition, the level of regional economic development also significantly affected the spatial pattern of commercial sports facilities in Xi 'an, and the explanatory power of night lighting index and per capita income were 0.375 and 0.154, respectively, indicating that the layout of commercial sports facilities in Xi 'an has a strong economic orientation. Population is an important market basis for the distribution of commercial sports facilities. The explanatory power of street population density on the spatial distribution of commercial sports facilities in Xi 'an is relatively significant, and its explanatory power is 0.431.

6. CONCLUSION AND DISCUSSION

This paper takes the commercial sports facilities of Xi 'an city as the research object, and summarizes the space-time evolution mechanism of the commercial sports facilities of Xi 'an city through analysis. From the perspective of spatial distribution, the overall distribution of commercial sports facilities in Xi'an is unbalanced, the expansion direction is consistent with the urban development direction, and the small-range cluster in the early stage has evolved into a multi-core cluster structure. From the perspective of influencing factors of spatial pattern, traffic factors, economic factors, population factors and spatial location factors all have a positive impact on the spatial distribution of commercial sports facilities in Xi 'an. Road network density has the greatest impact on the spatial distribution of commercial sports facilities in Xi 'an, followed by population density, night light index and distance between streets and the city center. The density of bus and subway stations, per capita income and distance from universities have little influence.

It is undeniable that this study only focused on commercial sports facilities in terms of facility types, and did not include other types of sports facilities in the study, so the scope of research samples can be increased in the future. In terms of research content, this paper only uses POI data to analyze the spatial distribution characteristics and influencing factors of commercial sports facilities in Xi 'an city, and does not pay attention to consumer demand, behavior rules and satisfaction, etc. In the future, further research can be conducted from the perspective of humanism.

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