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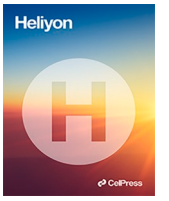

# Spatial distribution and driving factors of Chinese dragon and lion dance athletes based on GIS

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ABSTRACT

As the common wealth of all mankind, intangible cultural heritage carries the memory of history. The implementation of dragon and lion dance technical grade evaluation can be called pioneering work for the legacy inheritance. The purpose of this study is to analyze the distribution characteristics, trends, types, and driving factors of dragon and lion dance athletes. Athletes who were awarded a grade certificate by Chinese Dragon and Lion Dance Sports Association from 2018 to 2021 were taken as the analysis objects. In ArcGIS10.8, trend surface analysis and standard deviational ellipse are used to study the spatial distribution characteristics. Using the global and local Moran's I in GeoDa, this paper explores the concentration degree and types of dragon and lion dance athletes. The factors driving the distribution difference are analyzed with the help of geographical detectors. Continuous data such as total GDP, sports field areas, permanent populations, and altitude are taken as the software input after preprocessing. The results show that there are significant differences in the distribution of provinces and four geographical regions. For dragon dance athletes, there is a linear growth trend in the west-east direction and an inverted U-shape trend in the south-north direction. For lion dance athletes, there is a trend of log function in the west-east direction and an inverted U shape in the south-north direction. The global Moran's I is 0.2386, and there are obvious characteristics of H–H, L-L, and L-H aggregation types. Nomination of sports intangible cultural heritage, total GDP, permanent resident population, urbanization development level, the number of colleges and universities, and the proportion of tertiary industry are the leading factors, and the explanatory power of interactive factors is significantly enhanced. Therefore, it is suggested to strengthen the cultural heritage protection of dragon and lion dance, increase capital investment, enhance public participation, and raise government attention.

## 1. Introduction

Dragon and lion culture was born in the farming society and originated from people's respect for and belief in totems of praying for a bumper harvest in the coming year, good luck for the country and people's peaceful life [1]. With the development of society, the sport of dragon and lion dance has gradually developed into a traditional folk entertainment activity in China [2]. To adapt to the changing times, the dragon dance was approved as a competitive event in 1994. The establishment of the Chinese Dragon and Lion Dance Sports Association in 1995 marked the beginning of a new mission for the modern dragon and lion dance sport, which integrates

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artistic forms such as martial arts, music, dance, skills, etc. Based on the traditional dragon and lion dance sport and has gradually developed into a competitive sport that incorporates competitiveness, performance, and appreciation [3]. Since 2004, over 300 colleges and universities have established dragon and lion dance teams and courses as part of the "Dragon and Lion Dance Classes in 100 Schools in China" initiative." [4].

In 2016, the "Healthy China 2030″ Planning Outline put forward the strategic plan of "extensively carrying out national fitness activities and promoting the development of traditional ethnic and folk sports". At the same time, high-level competitive sports can play an exemplary and driving role in mass sports, attracting the public to participate in physical exercise. Transformation and use of any sports technology, training methods, advanced scientific and technological innovation, as well as development in the sports field begin with competitive sports and will be extended to mass sports [5]. Compared with other competitive events, the dragon and lion dance has a unique oriental sports style, which is reflected in the beauty of the spirit, the body, and the art. To stand out in international competitions, dragon and lion dance athletes need to combine music and dance to create a highly ornamental artistic performance [6]. Athletes are not only the main body of competitive dragon and lion dance but also the entity of artistic expression. Studying the spatial distribution of athletes will contribute to the development of competitive dragon and lion dance, thus driving the public to participate in dragon dance for fitness and improving the physical quality of the whole people.

Dragon and lion dance athletes belong to competitive sports talents, which are a special type of talents. At present, research on the geographical distribution of foreign talents is different from that of domestic talents. Foreign research focuses on human capital and innovative talents, and the research content includes human capital and regional development [7–9], talent spatial distribution and influencing factors [10–13], and female talent geographical distribution [14–16]. Compared with foreign research, domestic research focuses on the geographical distribution of talents in various dynasties [17–19], the distribution of talents at all levels of administrative regions [20,21], and the talent distribution in various fields [22,23]. At present, more research focuses on the description of the present situation. Few articles use exploratory data and geographic detectors to study the talent distribution. In addition, the relevant research further explores the causes of the talent distribution [24], and the strategy of balanced development between regions is discussed [25] on this basis.

Chinese scholars have studied the dragon and lion dance sport from different perspectives, and the research mainly involves the origin and development [26–31], physical fitness [32–35], college curriculum development [36,37], and sports value [38,39], etc. Scholars mainly elaborate on the artistic expression, physical fitness, and competitive ability of dragon and lion dance athletes, which are all from the microscopic point of view to study the athletes themselves. At present, there is no research on the spatial distribution and agglomeration characteristics of dragon and lion dance athletes from the macroscopic point of view. Therefore, this study explores the spatial distribution characteristics of dragon and lion dance athletes with the methods of spatial trend analysis, standard deviational ellipse, and exploratory data analysis, and the differentiation and mutual coupling relationship of driving factors are analyzed with geographical detectors. The study aims to understand the distribution characteristics and laws of dragon and lion dance athletes and provide a certain reference and basis for the national and local governments to plan the macro development of dragon and lion dance sport.

## 2. Research data and methods

### *2.1. Data sources*

Dragon and Lion Dance Grade Certificates by the Chinese Dragon and Lion Dance Sports Association from 2018 to 2021 were taken as the research objects. The reason for selecting this period is that the implementation of Athletes' Technical Level Announcement began in 2018. To scientifically analyze the spatial distribution characteristics of the sport, this study chose the provincial administrative regions of China as the research scale. Because the dragon and lion dance is a team event, the sport's specific position on the provincial scale is not analyzed.

The athlete-related information data came from the official website of the Chinese Dragon and Lion Dance Sports Association (http://dragonlion.sport.org.cn), including the representative units, competition time, award levels, etc. The data on total GDP, the proportion of the tertiary industry, and the permanent resident population from 2018 to 2020 were derived from the statistical yearbooks of each city. Altitude data came from the Resources and Environment Science Data Center of the China Academy of Sciences (http://www.resdc.cn). The method of obtaining the frequency of the keywords "dragon and lion" was to enter the number of the keywords "dragon and lion" in the search pages of the municipal people's governments and sports bureaus. The nomination data of sports intangible cultural heritage came from the Central People's Government of the People's Republic of China (PRC) (http://www.gov.cn). The number of nominations for dragon and lion dance sport in the five batches of national intangible cultural heritage lists published by the State Council was calculated. According to the classified statistics of the prefecture-level cities where the declared areas were located, 67 intangible cultural heritage lists were obtained.

### *2.2. Research methods*

(1) Global trend analysis method

Global Trend Analysis Tool is to draw a three-dimensional trend chart based on the ArcGIS platform. This method was chosen because it can directly describe the changing trend of athletes in a specific direction. The Z-axis represents the number of athletes, the X-axis represents the east-west upward trend (the arrow indicates the east), and the Y-axis represents the south-north upward trend

(the arrow indicates the north).

(2) Standard deviational ellipse

Standard Deviational Ellipse (SDE) is a method that can represent the agglomeration characteristics and azimuth of geospatial elements in spatial statistical analysis [40]. The major axis and minor axis of the ellipse represent the dispersion degree of elements in the major trend and minor trend respectively. The azimuth of the ellipse indicates the main trend direction of the spatial distribution of elements. The average center of the ellipse indicates the relative position of the elements in the spatial distribution [41]. This method was chosen because it can not only calculate the major axis, minor axis, azimuth, and average center of an ellipse [42,43], the spatial concentration can also be calculated by comparing the ratio of the element ellipse to the reference ellipse. Based on the standard deviational ellipse method, Zhao Zuoquan's calculation method of ellipse spatial agglomeration degree judges whether there is a spatial agglomeration pattern in element distribution by comparing the ellipse of element distribution with the ellipse of reference distribution (Equation (1)) [44]. The reference distribution ellipse was assumed to be a random distribution of elements in the study area. Therefore, the area of each province in the study area was taken as the reference element. Then the reference distribution ellipse of any element in the study area was obtained.

$$A = \left| 1 - \frac{\text{Area}(\textit{Element distribution ellipse})}{\text{Area}\ (\ \textit{Reference distribution ellipse}\ )} \right| \tag{1}$$

The area is the elliptical area. The elliptical area of reference distribution was calculated by taking the area of each provincial administrative region in China as the factor benchmark. A is the degree of spatial concentration, which is between [0,1]. The closer the value A is to 1, the more obvious the spatial aggregation of dragon and lion dance athletes will be.

(3) Exploratory spatial data analysis

Exploratory Spatial Data Analysis (ESDA) is an analytical method to explore the spatial agglomeration characteristics and spatial distribution patterns based on spatial distribution data [45,46]. Exploratory data analysis was chosen because it can be used not only to analyze the whole situation but also to test the spatial agglomeration characteristics of elements locally. Therefore, this paper used the global Moran's I to analyze the spatial characteristics of elements in the whole country (Equation (2)).

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}(X_i - \overline{X})(X_j - \overline{X})}{S^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \tag{2}$$

$I$ is the global Moran's I value. $n$ is the total number of provinces where the elements are located. $W_{ij}$ is the spatial weight Rook matrix. $X_i$ and $X_j$ are the number of provinces where the elements are located. $\overline{X}$ is the average value of quantity. $S^2 = \frac{1}{n}\sum_{i=1}^{n}(X_i - \overline{X})^2$. The value range of $I$ is between [-1,1]. When $I > 0$ and the closer it is to 1, the higher the concentration degree of spatial distribution of factors among provinces will be. When $I = 0$, it means that the number of elements is randomly distributed spatially and there is no spatial correlation. When $I < 0$, the smaller the value is, the more obvious the difference in the spatial distribution of elements will be.

The local spatial autocorrelation index is an investigation of the spatial characteristics of elements in the local range (Equation (3)). Based on global spatial autocorrelation, that which local regions made great contributions were further explored.

$$I_p = \frac{\sum_{i=1}^{n} W_{ij}X_j}{\sum_{i=1}^{n} X_j} \tag{3}$$

$I_p$ is the local Moran index value. When $I_p > 0$, it means that a local region with many elements is surrounded by another local region with many elements (H–H type), or a local region with few elements is surrounded by another local region with few elements (L-L type). When $I_p < 0$, it means that a local area with many elements is surrounded by another local area with few elements (H-L type), or a local area with few elements is surrounded by another local area with many elements (L-H type).

(4) Geographic detector

Although the manifestations of dragon and lion dance sport are different, there is a high degree of consistency in symbolism, national cultural value identity, and function. Therefore, the research data were merged when studying the driving factors of the spatial distribution of dragon and lion dance athletes. After analyzing the data, to explore the spatial distribution driving factors scientifically, this paper took prefecture-level administrative regions as the statistical units. Geographic detectors are statistics that reveal the driving factors behind and the spatial patterns (Equation (4)). The reason why geographical detectors were used to analyze the driving factors of spatial distribution differences is that geographical detectors have two special advantages. One advantage is that quantitative and qualitative data can be input, and another advantage is that geographical detectors can analyze the influence degree

of interaction factors on dependent variables [47].

$$q = 1 - \frac{\sum_{h=1}^{L} N_h \sigma_h^2}{N\sigma^2} \tag{4}$$

$q$ is the degree of a certain influence factor (X) to explaining the spatial distribution (Y) spatial differentiation pattern of elements. The value range is between [0,1]. The closer the value is to 1, the higher the degree of interpretation of Y will be. $L$ is the number of driving factors. $h$ is the stratified sample size. $N_h$ and $N$ represent the number of units in $h$ and in the whole region respectively. $\sigma_h^2$ and $\sigma^2$ represent the variance of $h$ and of the whole region respectively.

## 3. Results and discussion

### 3.1. Spatial distribution characteristics of quantity

To visually show the number distribution of dragon and lion dance athletes nationwide, the natural fracture method was used in ArcGIS, the graded color was selected and used to represent the quantity. As shown in Table 1, from 2018 to 2021, a total of 630 dragon-dance athletes and 161 lion-dance athletes in China were awarded athlete certificates. As it can be seen from Fig. 1, Jiangsu, Hubei, and Zhejiang provinces had more dragon-dance athletes. These areas are economically developed centers, including the Yangtze River Delta urban agglomeration, Chengdu-Chongqing urban agglomeration, and Wuhan urban agglomeration in China. There were more lion-dance athletes in Hubei, Guangdong, and Beijing (Fig. 2). These areas are in China's Beijing-Tianjin-Hebei urban agglomeration, Pearl River Delta urban agglomeration, and the Wuhan city circle, which are not only political centers but also regional economic centers. It showed that the distribution of dragon and lion dance athletes was related to regional politics and economy.

China has a vast territory and complex terrain. According to the classification method of the National Bureau of Statistics, Chinese territory is divided into four regions: east, west, middle, and northeast. To further analyze the distribution characteristics of dragon and lion dance athletes in China, this paper described and analyzed the athletes' number and proportion from four geographical divisions. As it can be seen from Table 1 and Fig. 3(A), the distribution of dragon dance athletes was significantly different, and the most distributed area of the athletes was the eastern region, accounting for 56.19 % of the total, in which athletes were mainly distributed in economically developed coastal areas, such as Jiangsu, Zhejiang, and Shanghai. Followed by the central region with a total of 156 dragon dance athletes, accounting for 24.76 % of the total (Fig. 3(A)). These athletes were mainly distributed in cities such as Wuhan and Changsha. The western region ranked third, with 109 athletes, accounting for 17.3 % of the total (Fig. 3(A)). Northeast China had the fewest athletes, with 11 being all distributed in Jilin, accounting for 1.75 % of the total (Figs. 1 and 3(A)).

By analyzing the statistical results of the distribution of lion-dance athletes in the four regions (Table 1), we can find that the distribution was highly concentrated and there were obvious differences between regions. 58.39 % of the athletes were distributed in the eastern region, mainly in Guangdong Province and Beijing (Figs. 2 and 3(B)). 30.43 % of the athletes were distributed in Hubei Province of the central region. There were 18 athletes in the western region, accounting for 11.18 % of the total number, who were mainly distributed in Sichuan Province and Shaanxi Province. From the results, we can see that different regions had different emphases, which may be related to regional cultures.

### 3.2. Trend characteristics of quantitative space

Trend surface analysis in ArcGIS10.8 was used. To draw the trend chart clearly, the X, Y, and Z coordinate lines were all given a value of 3. The curve was then set the colors shown in Fig. 4. As it can be seen from Fig. 4(A), the dragon dance athletes had an approximate linear growth trend in the west-east direction, which showed a trend of being low in the west and high in the east. It shows that the number of economically developed coastal areas in the east was bigger than that in the inland areas in the west. It was inverted U-shaped in the south-north direction, showing an obvious trend of being high in the middle and low in the north and south (Fig. 4(A)). It shows that the number of athletes decreases from the central region to the north and south. The number of lion dance athletes approximated the trend of log function in the west-east direction, showing the trend of being low in the west and high in the middle and east (Fig. 4(B)). It showed that there were fewer inland areas in west China and more athletes in middle and eastern China. In the south-north direction, there was no obvious inverted U-shaped trend, but it can be seen that in the middle, it was high and in the south it was low (Fig. 4(B)). This showed that the number in the central region was bigger than that in the north and south regions.

**Table 1**
Number of dragon and lion dance athletes in the four major regions.

| Event | Four geographical regions | | | | Total |
|---|---|---|---|---|---|
| | Eastern | Central | Westward | Northeast | |
| Dragon Dance | 354 | 156 | 109 | 11 | 630 |
| Lion Dance | 94 | 49 | 18 | 0 | 161 |

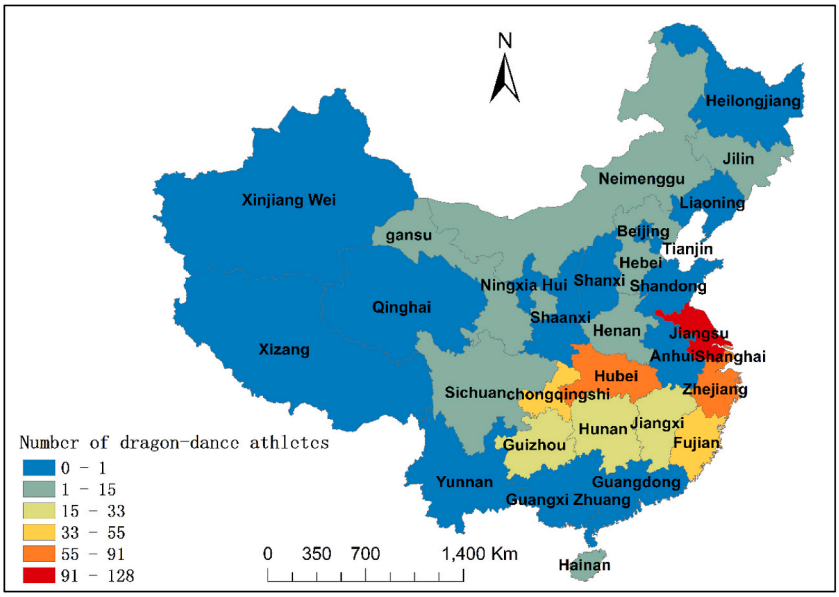


**Fig. 1.** Spatial distribution pattern of dragon-dance athletes.

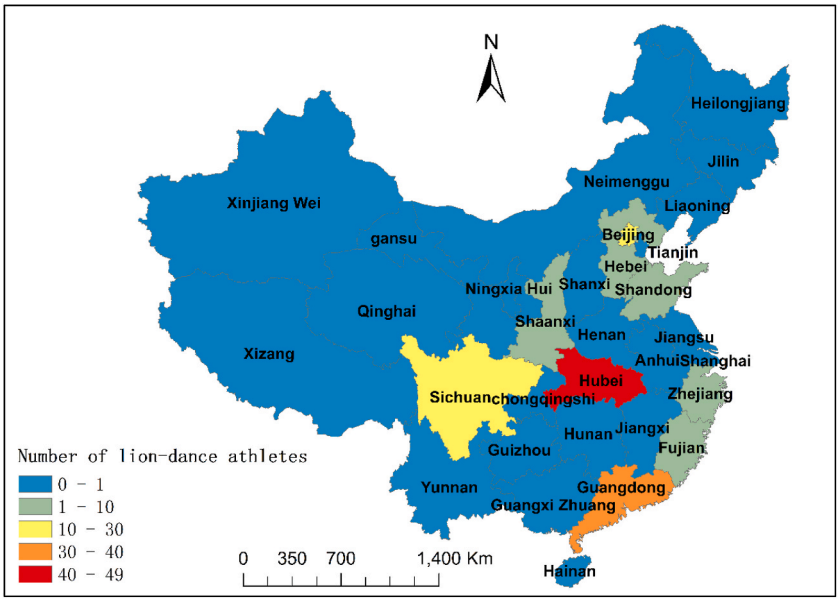


**Fig. 2.** Spatial distribution pattern of lion-dance athletes.

### *3.3. Spatial agglomeration of regional distribution*

Through the above spatial visual analysis and trend analysis of athletes, it can be seen that the spatial distribution was extremely unbalanced. Therefore, to further explore the spatial distribution and agglomeration characteristics of dragon and lion dance athletes in China, this paper explored the spatial distribution and agglomeration characteristics based on standard deviational ellipse and exploratory data analysis respectively.

#### *3.3.1. Characteristics of agglomeration degree*

ArcGIS for the rasterization of the data of dragon and lion dance athletes in different regions was used with the combination of standard deviational ellipse in spatial statistics. Then the base map data element class was imported. Finally, the ellipse size and weight fields were selected. In addition, for the element distribution ellipse and reference distribution ellipse, the default value of ellipse size

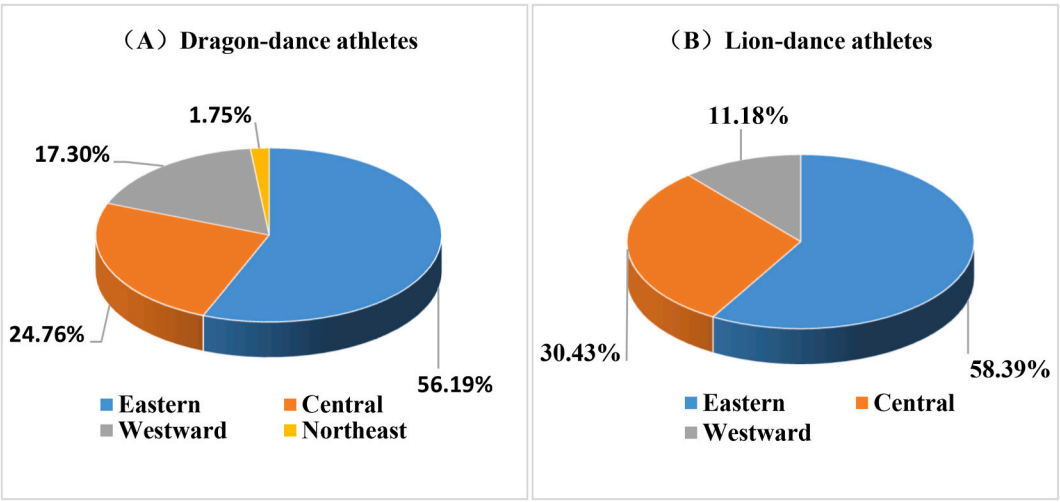


**Fig. 3.** Proportion in the four major regions of dragon and lion dance athletes.

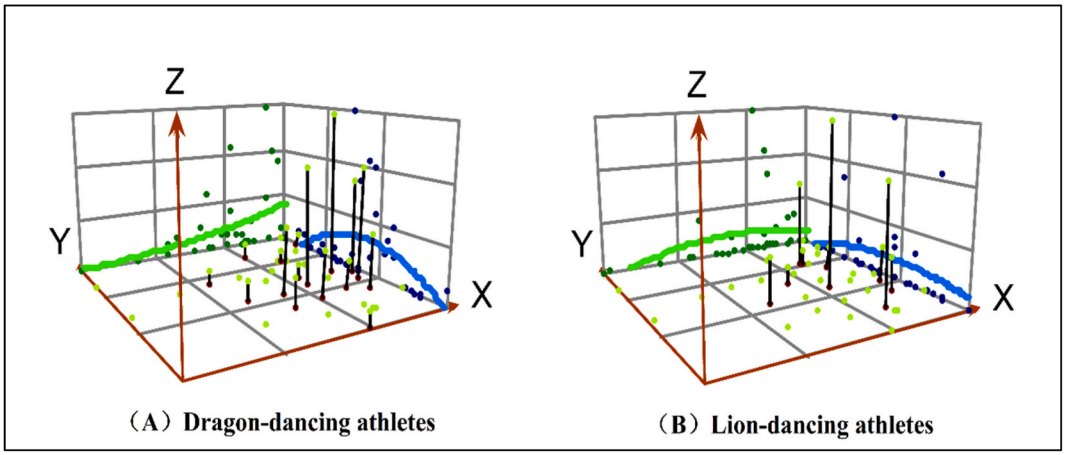


**Fig. 4.** Trend chart of dragon and lion dance athletes.

was selected. The corresponding data of ellipse can be obtained and the spatial agglomeration degree can be calculated by the ratio of ellipse area. As shown in Table 2, the spatial center of China's provincial administrative region (reference ellipse) was (111.81 E, 32.88 N), which was located in Henan Province. The major axis of the ellipse was 1142.04 km, the minor axis was 1162.24 km, the azimuth angle was 44.78, and the basic distribution ellipse area was 4169710.69 square km. Dragon-dance athletes were generally in the central and eastern coastal areas, and the spatial center was (115.71 E, 31.03 N), which was at the junction of Hubei Province and Anhui Province. The major axis was 746.66 km, the minor axis was 582.82 km, the azimuth angle was 62.26, and the spatial concentration was 0.67. The spatial center of lion dance athletes was (113.51 E, 31.35 N), which was in Hubei Province with a major axis of 543.08 km, a minor axis of 895.54 km, an azimuth of 0.39 and a spatial concentration of 0.63. From the central coordinates, the spatial distribution of dragon-dance athletes was closer to the eastern coast than that of lion-dance athletes, and the dispersion degree of lion-dance athletes in the main trend was higher than that of dragon-dance athletes. The spatial distribution of athletes was highly concentrated.

**Table 2**
Dragon and lion dance athletes' standard deviational ellipse related parameters.

| | Center coordinates | major axis (km) | Minor axis (km) | Azimuth (°) | Elliptical area ($km^2$) | Agglomeration |
|---|---|---|---|---|---|---|
| Provincial-level administrative districts | 111.81°E, 32.88°N | 1142.04 | 1162.24 | 44.78 | 4169710.69 | |
| Dragon Dance | 115.71°E, 31.03°N | 746.66 | 582.82 | 62.26 | 1367033.40 | 0.67 |
| Lion Dance | 113.51°E, 31.35°N | 543.08 | 895.54 | 0.39 | 1527800.77 | 0.63 |

#### 3.3.2. Characteristics of agglomeration type

To further reveal the spatial distribution and agglomeration characteristics of dragon and lion dance athletes, the spatial data of dragon and lion dance athletes were merged. The base map of the study area was imported into GeoDa software and the spatial data was merged. Then the ID variable and Rook adjacency weight matrix in spatial weight management were selected. The Rook weight matrix was chosen because there was no common vertex connection in each interval. Finally, the data results were obtained by univariate Moran's *I* and univariate local Moran's *I* in space (Table 3, Fig. 5, Fig. 6). As it can be seen from Table 3, the global Moran index was 0.2386, and the Z score was 1.8422, which was significant at the level of 5 %. It showed that there were positive spatial autocorrelation characteristics in spatial distribution.

The Global Moran's I can reflect the overall spatial agglomeration of the study area. However, when there are great differences between the study areas, it is necessary to introduce local spatial autocorrelation to explore the agglomeration characteristics between the units in the study areas. Moran's I scatterplot and LISA cluster map of the spatial distribution of dragon and lion dance athletes were obtained by GeoDa software. Then, the result was visualized by ArcGIS software. As it can be seen from Figs. 5 and 6, dragon and lion dance athletes had obvious characteristics of H–H type, L-L type, and L-H type. Zhejiang and Shanghai were located in the H–H cluster (the first quadrant). L-L type agglomeration area was located in Hebei Province and Inner Mongolia. The L-H cluster was located in Jiangxi Province. There was no H-L type agglomeration area, which showed that there were obvious overall spatial agglomeration characteristics.

### 3.4. Driving factors of distribution difference between dragon and lion dance athletes

#### 3.4.1. Selection of driving factors

As an outstanding representative of Chinese traditional sports, the dragon and lion dance has unique connotation characteristics [19]. Based on the connotation of the spatial distribution characteristics of dragon and lion dance athletes and drawing on existing relevant research [48–51]. 10 possible driving factors were selected from the five levels for statistical analysis in Table 4, i.e. politics, economy, society, culture, and nature, namely total GDP (X1), the proportion of tertiary industry (X2), permanent resident population (X3), the number of colleges and universities (X4), urbanization development level (X5), cultural, sports and media expenditure (X6), altitude (X7), sports area (X8), Keywords: "Dragon and lion " frequency number (X9) and sports intangible cultural heritage (X10).

#### 3.4.2. Analysis of single factor detection results

The independent variables and dependent variables input into the geographic detector must be category data. If it is continuous data, the data must be converted into category data first. For Raster data, it can be reclassified by raster. For vector data, sampling fishing nets can be used. The natural discontinuity classification method (Jenks) in ArcGIS is to set the boundary where the data values are relatively different. Therefore, with the help of ArcGIS software, the data of each factor were classified by natural discontinuity points, reclassified, and sampled. Then, the classified factor data was imported into the geographic detector.

As shown in Table 5, all the driving factors passed the 1 % significance level test, which had a significant positive effect on the dragon and lion dance athletes and achieved the expected results. In terms of Q value, the sports intangible cultural heritage (X10 (0.723)), total GDP (X1(0.636)), permanent population (X3(0.599)), level of urbanization (X5(0.523)), the number of colleges and universities (X4(0.521)) and the proportion of tertiary industry were the leading factors. The q value of sports intangible cultural heritage was 0.723, which had the highest degree of explanation. It showed that local culture had a great influence on the number of dragon and lion dance athletes. The permanent population is the main body of social development and the carrier of traditional culture inheritance which represents social productive forces. Cities with a large population such as Shanghai, Nanjing, and Wuhan had more athletes.

It was found that among many economic factors, the two leading driving factors affecting dragon and lion dance athletes were GDP and the proportion of tertiary industry. The q values of single factor detection results were 0.636 and 0.499 respectively. GDP reflects a city's economic strength, living standards, and development prospects. Stronger regional economic strength will bring more funds into talent training and the construction of talent base will also be strengthened. That is, the higher the regional GDP is, the more perfect the athlete training mechanism will be. The higher the proportion of the tertiary industry is, the greater the potential of a city in science and technology and cultural creativity will be. The application of high-tech technology in the competition will improve the competitive level of athletes.

#### 3.4.3. Analysis of interaction factor detection results

To more intuitively analyze the driving force and driving type of the two-factor interaction result, the interaction factor detection results were imported into OriginPro2022. Then the labeled heat map was selected in the drawing. In addition, the heat map was obtained after beautification treatment (Fig. 7). The judgment mode of each interaction factor type is shown in the illustration. On the whole, the explanatory degree of interactive factors was higher than that of a single factor on the spatial differentiation of dragon and

**Table 3**
Global Moran's I of dragon and lion dance athletes.

| Index | Moran's *I* | Z value | P value |
|---|---|---|---|
| Numerical value | 0.238552 | 1.8422 | 0.048 |

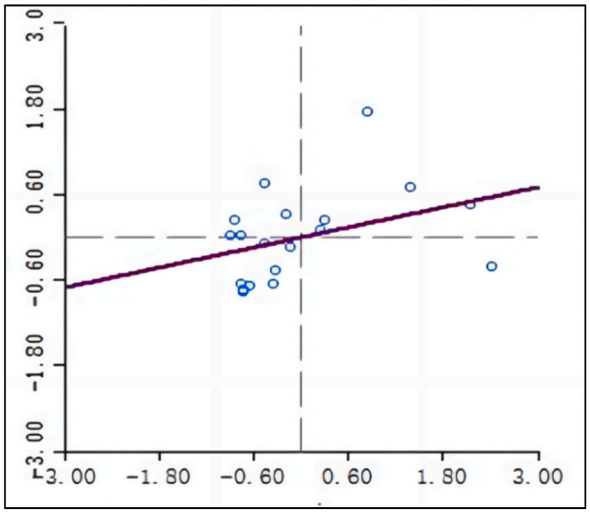


**Fig. 5.** Spatial distribution of dragon and lion dance athletes Moran scatterplot.

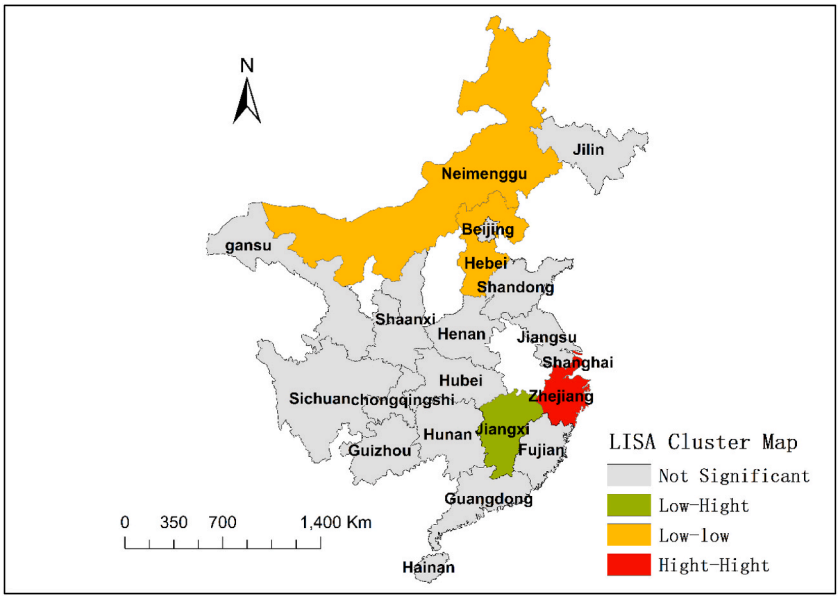


**Fig. 6.** Spatial distribution of dragon and lion dance athletes LISA cluster map.

lion dance athletes. All interaction factors showed two-factor enhancement and nonlinear enhancement. The order of nonlinear enhancement types was: X9∩X5(0.998) > X9∩X1(0.956) > X9∩X2(0.928) > X4∩X8(0.919) > X9∩X3(0.9) > X5∩X8 ( 0.889 ) > X8∩X9 ( 0.859 ) > X2∩X7 ( 0.69 ) > X5∩X7 ( 0.64 ) > X9∩X7 ( 0.586 ) > X6∩X7 ( 0.579 ) > X7∩X8 ( 0.552 ) .

From the single factor results, the frequency of the keyword "dragon and lion" (0.313) could not be used as the dominant factor. However, the interaction results of the keyword "dragon and lion" frequency (X9) with the level of urbanization (X5), the total GDP (X1), and the proportion of the tertiary industry (X2) were 0.998, 0.956, and 0.928 respectively. It can be found that the interaction results between the frequency of "dragon and lion" and other factors were significantly improved, and many interaction factors showed nonlinear enhancement. It fully showed that the distribution difference between dragon and lion dance athletes was related to local policies.

The top three combinations of the interaction results between the area of sports ground (X8) and other factors were X8∩ the number of colleges and universities (X4(0.919)), X8∩ the level of urbanization (X5(0.889)), and X8∩ the frequency of keywords "dragon and lion" (X9(0.859). All of the above were nonlinear enhancements, indicating that the area of sports venues was also an important driving factor. With the development of modern competitive dragon and lion dance, the requirements for venues are getting higher and higher. Hardware including venues can be guaranteed, and the level of dragon and lion dance athletes can be significantly improved.

**Table 4**
Driving factors of the spatial distribution of dragon and lion dance athletes.

| Level 1 factor | Level 2 factor | Level 3 factor | Explanatory variable |
|---|---|---|---|
| Economy | Level of economic development | Total GDP (X1) | Average GDP of prefecture-level cities from 2018 to 2022 |
| | | Proportion of tertiary industry (X2) | The average proportion of tertiary industry in prefecture-level cities from 2018 to 2022 |
| | | Cultural, sports, and media expenditure (X6) | Average expenditure on culture, sports, and media in prefecture-level cities from 2018 to 2022 |
| Society | Level of social development | Number of colleges and universities (X4) | Total number of colleges and universities in prefecture-level cities |
| | | Urbanization development level (X5) | Average level of urbanization development in prefecture-level cities from 2018 to 2022 |
| | Demographic base | permanent population (X3) | Average resident population of prefecture-level cities from 2018 to 2022 |
| | Level of sports development | Sports area (X8) | Area of sports area in prefecture-level cities |
| Nature | Physical geography | Altitude (X7) | Average elevation of prefecture-level cities |
| Political | Government attention | Keywords: "Dragon and lion " frequency number (X9) | The frequency of "Dragon and Lion" appeared in the reports of local municipal governments and sports bureaus. |
| Cultural | Traditional culture | Sports intangible cultural heritage (X10) | Nominations of dragon and lion in five batches of national intangible cultural heritage in prefecture-level cities |

**Table 5**
Spatial differentiation of dragon and lion dance athletes results of unifactorial detection.

| Factor | Q | P | Q sorting |
|---|---|---|---|
| X1 | 0.636 | 0.00 | 2 |
| X2 | 0.499 | 0.00 | 6 |
| X3 | 0.599 | 0.00 | 3 |
| X4 | 0.521 | 0.00 | 5 |
| X5 | 0.523 | 0.00 | 4 |
| X6 | 0.453 | 0.00 | 7 |
| X7 | 0.103 | 0.00 | 10 |
| X8 | 0.340 | 0.00 | 8 |
| X9 | 0.313 | 0.00 | 9 |
| X10 | 0.723 | 0.00 | 1 |

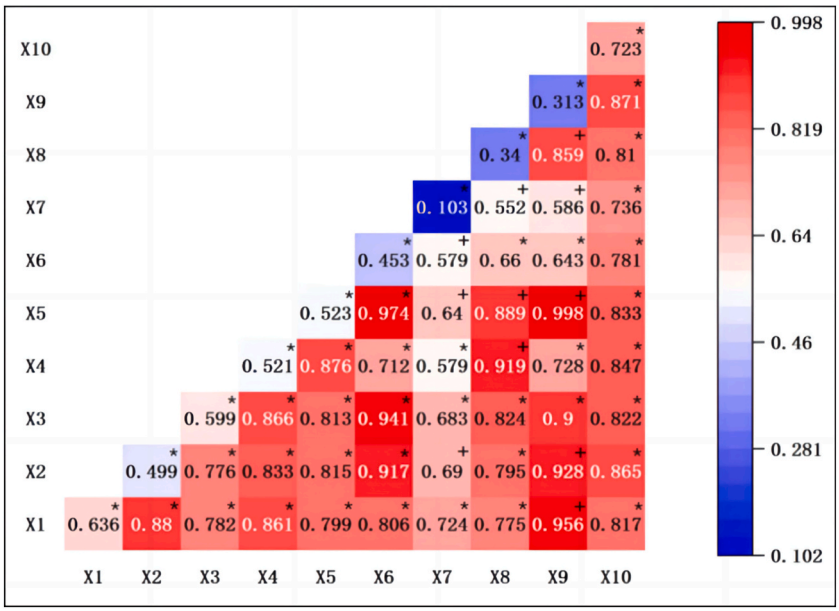


**Fig. 7.** Detection results of spatial differentiation interaction factor of dragon and lion dance athletes
Note: * indicates two-factor enhancement [q(Xp∩Xq) > Max(Xp,Xq)], + indicates nonlinear enhancement [q(Xp∩Xq) > (Xp + Xq)].

The results of interactive factor detection showed that the maximum combination was the level of urbanization (X5)∩ the frequency of the keyword "dragon and lion" (X9), and the degree of explanation was as high as 0.998. The explanatory power of several interactive factors, such as X1∩X9, X2∩X6, X2∩X9, and X3∩X6 reached 0.900 or above, indicating that the spatial differentiation of dragon and lion dance athletes was the result of the interaction of many factors.

## 4. Conclusion and future research

### *4.1. Conclusion*

The inheritance and development of intangible cultural heritage is one of the top agendas in the world today. Dragon and lion dance is not only a Chinese sport but also the world's cultural heritage. Cultivating dragon and lion dance athletes is pioneering work that conforms to the development of the times. Due to the influence of the regional economy, culture, and policies, dragon dance athletes are mainly distributed in economically developed areas, such as the eastern coastal areas and Hubei province. Lion dance athletes are mainly distributed in political and economic centers, such as Hubei, Guangdong, and Beijing. For the results of clustering characteristics, the spatial distribution of dragon and lion dance athletes was highly clustered, and local Moran's I scatterplot was mostly distributed in the first and third quadrant. The leading factors of the distribution difference between dragon and lion dance athletes in the study area were the nomination of sports intangible cultural heritage, the total GDP, the permanent population, the level of urbanization development, the number of colleges and universities, and the proportion of tertiary industry. Degree of the results of interaction factors was greater than the driving degree of a single factor, which showed that the spatial differentiation of dragon and lion dance athletes was the result of interaction of multiple factors. Therefore, it is necessary to strengthen the protection of the dragon and lion dance cultural heritage, increase capital investment, enhance public participation, and raise government attention.

### *4.2. Limitations and future research*

The analysis of limitations of prior research has expanded the possible areas for future research on the dragon and lion project. Because of the limitation of research data, the spatial evolution trend is not predicted. Therefore, this section provides a valuable direction for scholars' follow-up research. In addition, taking into account the enactment of targeted policies and initiatives by policymakers. Therefore, it remains to be tested to dig deep into their influence from the perspective of time.

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**Data availability statement**

The data that support the findings of this study are available from the corresponding author, [Jian Zhang, a15353719476@163.com], upon reasonable request.

**Ethical statement and informed consent**

Not applicable.

**CRediT authorship contribution statement**

**Erlong Liu:** Writing – original draft, Formal analysis, Data curation. **Jian Zhang:** Writing – review & editing, Formal analysis, Data curation, Conceptualization. **Haonan Chi:** Formal analysis, Data curation.

**Declaration of competing interest**

The authors declare no competing conflicts of interest.

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**Appendix A. Supplementary data**

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e23409.

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