From zero to hero: the spatio-temporal patterns and migration influence mechanism of world-class athletes in China

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A R T I C L E  I N F O

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Migration influence mechanism

A B S T R A C T

At present, China is in an important stage of transition into a global sports power where “outstanding competitive sports talents” are required to play an important role. Therefore, it is of great theoretical and practical significance to conduct in-depth research on domestic “outstanding competitive sports talents” to promote the sustainable development of China's competitive sports and enhance its comprehensive strength. In this study, WCA refers to “world-class athletes,” indicating a group of talents who won medals in international sports events such as the Olympic Games during 2009–2019. In this regard, this study uses statistical and spatial analysis methods to reveal the spatial and temporal characteristics, evolutionary process, and migration mechanism of Chinese WCA. The conclusion shows that: In terms of temporal characteristics, the population numbers in general and among different genders are characterized by a “three peaks and two troughs” pattern. In contrast, the individual temporal pattern is characterized by an “inverted U” and “inverted V”, with an average age of 23.18 years. In terms of space, a positive correlation is shown on the whole (Moran's $I > 0$), however, characteristics of geographical proximity and spatial heterogeneity are not prominent, illustrating the spatial form of random distribution with low aggregation which is primarily concentrated in the southeast of China and demonstrates a “northeast-southwest” trend. There are apparent differences between areas of origin and immigration areas: Liaoning and Shandong are the main areas of origin while destination areas are frequently located in the southeast and “People's Liberation Army of China” (PLA for short). Lastly, this paper discusses the causes and influences of the migration groups from three aspects: the migrating talents, the areas of origin and immigration areas, and Chinese sports, revealing the formation and influence mechanisms.

1. Introduction

The concept of “outstanding competitive sports talents” is grounded in the concept of sports talents, giving consideration to their field of expertise and sports activities, and is based on the identification of talents who achieve outstanding results and major contributions in competitive sports (National Bureau of Statistics, 2018). As the highest title for extraneous competitive sports talents, the title “World-class athletes” (WCAs for short) is given to athletes when they enter particular ranks or complete certain achievements in world-class games (For example, the Olympic Games, world championships, world cup and so on). The launch of the plan “Outline for Building a Leading Sports Nation” by the General Office of the State in 2019 showed that enhancing the comprehensive strength of these athletic programs is crucial to China's goal of becoming a world sports power. Furthermore, the developmental landscape and regional evolution of competitive sports have become topics commonly discussed by scholars (Li 1998; Tian, 2000; Du, 2019). With the introduction of the market economy, institutional barriers to the mobility of outstanding athletes have been gradually broken. Since the early 1990s, there has been increasing mobility of national and international competitive sports talents, which is a typical geographic research problem. How to examine the phenomenon of mobility (talent migration) from multiple perspectives, analyze and objectively evaluate the deep-seated reasons behind talent mobility, and crack the talent mobility

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problem has become an important issue in promoting the smooth development of Chinese sports. Current research has identified several key challenges, as noted below.

Subjects: Medal winners of various sports competitions form the majority of research subjects, including, for instance, gold medal winners from the National Games of the People’s Republic of China (Gao, 2008), world-class elite men’s high jumpers (Qiu et al., 2011), medal winners from Winter Olympics (Wang et al., 2019), winner of Olympic men’s weightlifting (Yang, 2019), athletes from London Olympics’ men’s basketball teams (Zhang et al., 2014), and medal winners of the past Olympic games (Hu, 2013; Shi and Yang, 2009; Wu et al., 2018; Zhao et al., 2013).

Methodologies: Mathematical statistics and comparative analysis are the main methodologies applied in the studies. By performing a statistical analysis on the data of the WCAs and migrant talents, the methodologies can describe the basic characteristics (including population, age, gender, physical condition, etc.) of the subjects and draw conclusions of present trends from a special distribution approach (Gao, 2008; Li, 1996; Luo, 2005; Shi and Yang, 2009; Zheng et al., 2019). Certain scholars also have applied research methodologies in analyzing the geographical features of the migration. For example, the spatial and temporal distribution and their cause (Chen et al., 2018; Jiang et al., 2018; Wu et al., 2018; Wang et al., 2019; Yu et al., 2004), employs the push-pull theory of migration to explain the formation and migration mechanism of the Chinese table tennis “sea drifters.” (The push-pull theory refers to the fact that population migration is driven by a combination of push forces in the out-migration area and pull forces in the in-migration area, with various favorable factors in the in-migration area creating a pull force that drives migration.) (Li et al., 2019).

To sum up, in the study of WCAs and their geographical distribution, previous research have displayed the lack of diversity in the types of WCAs. Additionally, the discussions regarding talent migration are mostly performed from a general perspective, and the analysis are namely descriptive with statistical analysis serve only as supporting texts of 175 people who had migrated in detail through the internet, from which we extracted and analyzed the motivation, time, and process of migration to support the study of migration influence mechanism.

2. Materials and methods

2.1. Dataset

This paper analyzes the group of WCAs participating in the international sports games (Olympic Events) from 2009 to 2019. A database has been created from essay research and official website data and has been verified using historical reference and comparison. The database contains 1342 total entries, with more detailed information available as follows: 976 results are associated with detailed places of birth and years of birth, of which 175 have participated in sporting events on behalf of other regions because of the spatial migration (e.g., family moving across regions). The data represent 30 provinces as well as the other regions (e.g., family moving across regions) of birth, of which 175 have participated in sporting events on behalf of other regions because of the spatial migration (e.g., family moving across regions). The data were further classified into six detailed categories based on the cluster-based training theory (Tian, 2000). The data was ultimately classified into seven categories (See Table 1).

2.2. Methods

(1) Text Analysis

Text analysis refers to quantifying information by extracting the expression and features of the language, text, image, and so on. Based on the above-mentioned database, this study searched the growth history texts of 175 people who had migrated in detail through the internet, from which we extracted and analyzed the motivation, time, and process of migration to support the study of migration influence mechanism.

(2) Standard Deviational Ellipse Analysis

Standard deviational ellipse (SDE) is a statistical method that is used to represent the spatial distribution characteristics of geographical features (Lefever, 1926). The semi-major axis represents the distribution direction of geographical elements, while the minor semi-axis represents the distribution range. The more significant the difference between the two is, the more apparent spatial directionality of geographical elements is. In this paper, the standard deviational ellipse is used to reveal the trend of the WCAs.

Mathematically, the formula can be expressed as:

\[
\text{SDE}_x = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}
\]

\[
\text{SDE}_y = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n}}
\]

where \(x_i\) and \(y_i\) represent the geographic coordinates of the WCAs i, \(\bar{x}\) and \(\bar{y}\) represent the average gravity center of the WCAs.

(3) Getis-Ord Gi*

Getis-Ord Gi* is used to reveal the spatial distribution of hot spots and cold spots (Hu et al., 2019). The calculation formula is:

\[
\text{Getis-Ord Gi*} = \frac{\sum_{i=1}^{n} W_{ij} g_i^2}{\sum_{i=1}^{n} \sum_{j=1}^{n} W_{ij} g_i g_j}
\]

where \(W_{ij}\) is a spatial weight matrix, \(g_i\) represents the value of the feature at location i.

Table 1. Classification and statistics of different sports groups.

| Categories | Based on which Criteria | Specific sports | Number |
|------------|------------------------|----------------|--------|
| I          | SO                     | Athletics, Weight lifting, Canoeing, Rowing, Sailing, Cycling, Modern Pentathlon, Swimming, Triathlon | 561    |
| II         | Skill-dominant: accuracy | Shooting, Archery | 92     |
| III        | Skill-dominant: difficulty and artistic | Gymnastics, Rhythmic gymnastics, Synchro swimming, Diving, Gymnastics trampoline | 147    |
| IV         | Skill-dominant: competitions in the same count | Football, Water polo, Handball, Hockey, Basketball | 144    |
| V          | Skill-dominant: competitions in net sports | Volleyball, Table Tennis, Badminton, Tennis | 130    |
| VI         | Skill-dominant: combat | Taekwondo, Fencing, Judo, Boxing, Wrestling | 197    |
| VII        | WO                     | Short track speed skating, Cross-country skiing, Snowboard, Speed skating, Biathlon, Ice hockey, Figure skating, Freestyle skiing, Hockey | 116    |
\[ G_i(d) = \sum_{j=1}^{n} W_{ij}(d) X_j / \sum_{j=1}^{n} X_j \]  

(3) After standardization:

\[ Z(G_i) = \left[ G_i - E(G_i) \right] / \sqrt{Var(G_i)} \]  

(4)

where \( x_j \) is the attribute value of element \( j \), \( W_{ij}(d) \) is the spatial weight between \( i \) and \( j \), \( n \) is the total number of elements. \( E(G_i) \) and \( Var(G_i) \) are the mathematical expectation and coefficient of variation of \( G_i \). When \( Z(G_i) \) is a positive value, and the value is larger, which means that the clusters of hot spots are more concentrated. When \( Z(G_i) \) is a negative value, and the value is smaller, which means that the clusters of cold spots are more concentrated.

(4) Moran's I index

Moran's I index evaluates spatial autocorrelation based on the locations and values of features. This index is measured by utilizing multidimensional and multi-directional factors. The Moran's I Index will be a value between -1 and 1. The results will be shown in three ways: (1) positive values (clustered spatial autocorrelation); (2) Negative values (dispersed spatial autocorrelation); (3) Zero (No clear spatial autocorrelation). In addition, LISA, which stands for the local indicator of spatial association, possesses two essential characteristics: (1) a statistic for each location with an evaluation of significance; and (2) a proportional relationship between the sum of the local statistics and a corresponding global statistic (Anselin, 1995).

3. Results

3.1. The basic characteristics

There are 524 male athletes and 818 female athletes, demonstrating an overall female strength and male weakness regarding the number of athletes. The subjects within the skill-dominant categories, especially the “Skill-dominant: competitions in the same court” section, demonstrated stark differences in gender participation. To be specific, ball events displayed such differences most prominently, followed by wrestling, swimming, cycling, and triathlon. In order to achieve a zero breakthrough, it is necessary to strengthen the selection and training of male athletes, particularly in the ball, wrestling, boxing, and taekwondo, as well as tennis, ice hockey, handball, and biathlon (See Table 2).

In terms of age distribution, the subjects presented a rather scattered distribution. The age of the subjects ranged between 14 and 40, including a low interval of 17–20 and a high interval of 17–38. The range indicated that most sports' WCAs minimum ages were rather similar while the highest ages were more diverse. According to the data, most WCAs’ age ranged between 20 to 26, with an average of 23.18, the lowest for a specific sport being 19.25 (swimming) and the highest being 28.33 (handball). The data displayed both similarities and differences among the different age groups, with evidence of connections between the age groups and the events: events belonging to groups such as “competitions in the same court”; “net sports” and “combat” tended to have older WCAs while events that were “difficulty and artistic” or “stamina-based” events contained younger WCAs.

3.2. Spatio-temporal features

3.2.1. General interannual changes

The interannual changes displayed a generally declining pattern with three peaks and two troughs (See Figure 1). Specifically, the three peaks decreased in magnitude over time while the two troughs remained the same. There was a drastic increase between the years 2009 and 2011, which is likely explained by the events that occurred in these specific years. The change beginning in 2009 reflected the fact that many potential candidates began active participation in sports events to further obtain relevant experience at the beginning of an Olympic four-year cycle. Likewise, the changes up to 2011 at the highest peak reflected the crucial year for talents to qualify for participation in the Olympic

| Categories | Sports | Gender | Male | Female | Age | Range | Span | Average |
|------------|--------|--------|------|--------|-----|-------|------|---------|
| I          | Swimming | Male   | 53   | 83     | 14-26| 12    | 19.25|         |
|            |         | Female |      |        |      |       |      |         |
|            | Athletics | Male   | 47   | 49     | 18-32| 14    | 23.59|         |
|            |         | Female |      |        |      |       |      |         |
|            | Rowing  | Male   | 39   | 52     | 19-37| 18    | 23.61|         |
|            |         | Female |      |        |      |       |      |         |
|            | Weightlifting | Male | 12   | 9      | 18-27| 9     | 21.78|         |
|            |         | Female |      |        |      |       |      |         |
|            | Sailing | Male   | 13   | 29     | 17-37| 20    | 24.13|         |
|            |         | Female |      |        |      |       |      |         |
|            | Canoeing | Male   | 22   | 16     | 17-32| 15    | 23    |         |
|            |         | Female |      |        |      |       |      |         |
|            | Cycling | Male   | 51   | 21     | 20-35| 15    | 22.61|         |
|            |         | Female |      |        |      |       |      |         |
|            | Triathlon | Male | 1    | 7      | 20-28| 8     | 25.75|         |
|            |         | Female |      |        |      |       |      |         |
|            | Modern Pentathlon | Male | 6    | 6      | 20-25| 5     | 22.13|         |
| III        | Shooting | Male   | 38   | 33     | 17-38| 21    | 24.7 |         |
|            |         | Female |      |        |      |       |      |         |
|            | Archery | Male   | 10   | 11     | 18-31| 13    | 22.53|         |
|            |         | Female |      |        |      |       |      |         |
|            | Diving  | Male   | 34   | 28     | 14-31| 17    | 20.11|         |
|            |         | Female |      |        |      |       |      |         |
|            | Gymnastics | Male | 16   | 13     | 16-29| 13    | 21.66|         |
|            |         | Female |      |        |      |       |      |         |
|            | Gymnastics trampoline | Male | 11   | 11     | 18-29| 11    | 22.23|         |
|            |         | Female |      |        |      |       |      |         |
|            | Rhythmic gymnastics | Male | 0    | 15     | 17-23| 6     | 20.4 |         |
|            |         | Female |      |        |      |       |      |         |
|            | Synchronized swimming | Male | 0    | 19     | 18-27| 9     | 22.14|         |
| IV         | Football | Male   | 1    | 43     | 22-33| 11    | 25.95|         |
|            |         | Female |      |        |      |       |      |         |
|            | Basketball | Male | 8    | 13     | 18-31| 13    | 25.81|         |
|            |         | Female |      |        |      |       |      |         |
|            | Handball | Male   | 0    | 3      | 27-30| 3     | 28.33|         |
|            |         | Female |      |        |      |       |      |         |
|            | Water polo | Male | 9    | 20     | 18-34| 16    | 24.75|         |
|            |         | Female |      |        |      |       |      |         |
|            | Hockey  | Male   | 1    | 46     | 19-27| 8     | 22.5 |         |
|            |         | Female |      |        |      |       |      |         |
| Total      |         | Male   | 524  | 818    | 14-40| 26    | 23.18|         |
|            |         | Female |      |        |      |       |      |         |

Notes: no athletes were given any titles in events of rugby, golf, equestrian, alpine skiing, snowmobiles, sleighing, Nordic combined, and skeleton; the gender statistics were based on all 1342 entries of the data; the statistics of age was based on the 976 entries with a clear description of the date of birth, and all ages were based on the age when the athletes received their WCAs title.
Games, especially when scores were considered in determining Olympic eligibility. The decrease from 2011 to 2012, the lowest peak, was due to China’s focus on the Olympic Games. The drop also reflected other considerations, including that most participants had already received the title before the event, participation frequency, the training cycle and retirement. The increase to a peak reemerged from 2012 to 2015, with the second highest peak occurring in 2015, before dropping to the lowest trough in 2017. Meanwhile, the third peak during 2018 was due to the lack of complete 2019 data.

The gender changes followed the trend of the three peaks and two troughs, with the number of female athletes higher than that of their male counterparts, except for the years 2010 and 2014. From a gender perspective, the numbers of female WCAs were rather stable with a slight increase, whereas male WCAs tended to decrease over time. This phenomenon suggests that such situation may continue to exist in China’s competitive sports going forward. Therefore, the decline of male WCAs is critical to the overall decreasing trend observed in the study.

3.2.2. Individual interannual changes

The numbers of WCAs born in different years displayed an “inverted U” shape, with a stark decrease before 1988 and after 1992 (See Figure 2a). Possible explanations for this particular shape include the
apparent lack of competitiveness for under-age and over-age talents and the one-child policy in China, with the resulting decrease in population affecting the available numbers of talents for the national competition teams (Wu et al., 2018). The decrease of WCAs born in 1991 specifically could potentially be traced back to this policy, as the overall population experienced a significant drop in 1991.

The ages of the individuals who received the WCAs title demonstrated an “inverted V” shape, with 22 being the peak (See Figure 2b). This trend could be further classified into three sections: the first being the peak age (from 19 to 27) when the athletes were in their best performance; the second being the secondary peaks (from 16 to 18 and 28 to 30); and the third being the special performance age (from 14 to 15, 31 to 40). The phenomenon of younger and older WCAs is influenced by several factors. Besides the idea of juvenile programs and adult programs stated by Tian Maijiu (Fan, 2019; Tian, 2000). Other factors, including scientific recruitment and training, awareness of preventing sports injuries and contemporary medical care, also contributed to the rapid development of athletes competition skills and longer career life.

3.3. Features of spatial evolution

3.3.1. General spatial distribution observations

This research applied ArcGIS to create a chart of the provincial distribution of China’s WCAs (See Figure 3 and Table 4). From the figure, the differences and imbalance of the provincial distribution is evident. The research classified the data into six groups based on the population of WCAs in each province. The first, 91 to 124; the second, 59 to 90; the third, 35 to 36; the fourth, 21 to 34; the fifth, 6 to 20; and the sixth, 0 to 9. Each group contained different provinces and regions: the first contained 4, including Liaoning and Shandong; the second contained 5, including Beijing and Heilongjiang; the third contained 6, including Hebei and Tianjin; the fourth contained provinces of Guangxi, Henan and Jilin; the fifth contained 7, including Inner Mongolia and Xinjiang; and the sixth contained 8, including Gansu and Ningxia. Based on the analysis, the provincial distribution of WCAs mainly focused on the following regions: Northeast China, North China (except Shanxi), East China (except Anhui and Jiangxi), South China, and Central China. The distribution showed a Northeast to Southwest trend and highly overlapped with the Southeast side of the Heihe-Tengchong line — the line dividing China’s geographic area (Equations (1) and (2)). The trend further indicates that regions with a larger population, greater economic development and higher sport awareness are likely to contain excellent talents.

3.3.2. Annual spatial changes

Spatial autocorrelation is one of the methodologies used to analyze spatial data and is featured in exposing spatial dependence, spatial heterogeneity, spatial correlation and congregation in data and variables. The research here illustrates the spatial features and spatial dependence of WCAs from 2009 to 2019, using GeoDa to create a Moran’s I index (See Table 5) and a LISA cluster map (See Figure 4).

From the data shown in Table 3, all data included in the Moran’s I index were above 0 and displayed a positive relation as well as a congregation feature of “high—high” and “low—low”. The data displayed the phenomenon that more developed provinces usually display a larger distribution of WCAs. Likewise, less-developed regions are more likely to show a small WCAs population. There is a certain geographical proximity in the distribution of “international athletes”, but the geographical proximity and spatial heterogeneity are not readily apparent, and the spatial distribution pattern is random with low aggregation. If we observe the Moran’s I index throughout the years, it is noticeable that there has been a clear “negative—positive—negative—positive” trend since 2012. The trend indicates how time and regional areas has affected WCAs population during different years. To be specific, during the years 2009, 2010, 2013, 2015, 2017 and 2019, the Moran’s I index has displayed positive results, which suggests a growing trend as well as the increase of a positive correlation. Meanwhile, the Moran’s I index has shown negative figures in the other years as well as a negative correlation. Given by duration of Olympics Games, it is likely to associate the data to the situation that WCAs have been preparing to participate in the Games during the time period. Z-scores indicate that the significance of the congregation varied over time. Among the years, 2012 and 2016 had the highest significance level, while the years 2010, 2013 and 2017 also displayed significant spatial congregation. Factors influencing this congregation include qualification, recruiting, winning rules, actual performance and migration.

Based on Figure 4, so far, it can be observed from the data that in most provinces, the distribution of WCAs in terms of spatial correlation appears without a distinct feature. However, it is still able to perceive that the data displays an obvious difference in both 2012 and 2016 due to the influence of the Summer Olympic Games, while other years also demonstrate a clear pattern of spatial correlation. The “high-high” pattern appears in North and East China, namely Shandong, Jiangsu, and Shanghai. These areas are regarded as the main bases for training WCAs, though they fail to connect in the form of a large-scale congregation. The “low-high” pattern mainly appears in Northeast and East China, with the examples of Jilin and Anhui. The reason for such a pattern is largely due to the mentioned areas’ close location around the provinces that excel in competitive sports. Furthermore, thanks to the strategy of sports development in the recent years, Sichuan has experienced a change from the “low-low” pattern to the “high-low” pattern, making it stands out as one of the most sports-developed provinces in Southwest China. As for the “low-low” pattern, which is especially prominent in Northwest and certain Southwest China regions—mainly in Shaanxi, Gansu, and Zhejiang, can be considered as the most popular pattern among all Chinese regions. This can be assumed by the fact that those regions have rather a small pool of WCAs. Regardless of the provincial support for sports, which reflects China’s current phase of shifting into a world sports power, there has been a diminishing trend throughout the years in the “low-low” pattern. However, the improvement is far from distinct (Equations (3) and (4)).

3.4. The evolution of WCAs’ migration patterns

3.4.1. Area of origin and destination area patterns

The migration of international athletes is essentially a cross-provincial talent migration. Therefore, according to the push-pull theory of population migration, the spatial pattern of the migrating group of international athletes” is analyzed from two aspects, namely, the place of departure and the place of entry. As shown in Figure 5, the values of the
international talents migrating from the outgoing places are marked in red, and those migrating from the incoming places are marked in black. The migrating group of international athletes in China covers 26 provinces (municipalities and autonomous regions), 21 provinces (municipalities and autonomous regions), the People’s Liberation Army (PLA), and one sports association. From a quantity perspective, there are apparent differences between the migrating and migrating provinces, and the migrating places are more concentrated than the migrating places. The migrating places are mainly distributed and located on the southeast side of the Hu Huanyong Line and the PLA. Among them, Liaoning (33), Shandong (14), Jiangsu (13), Heilongjiang (12), Henan (11), and Hubei (11) are the major emigration places (94 in total for the six places, accounting for 53.71% of the total). Guangdong (9), Hebei (7), Yunnan (7), Anhui (5), Zhejiang (5), and Chongqing (5) are the minor emigration places (38 in total for the six places, accounting for 21.71% of the total), with the rest of the out-migration places having a smaller number of international athletes. PLA (52), Guangdong (22), Beijing (19), and Shandong (14) as the main in-migration places (107 in total for the four places, accounting for 61.14% of the total). Besides, Shanghai (9), Zhejiang (8), Tianjin (7), Liaoning (6), Hunan (6), Shanghai (9), Zhejiang (8), Tianjin (7), Liaoning (6), Hunan (6), Jiangsu (5), and Sichuan (5) are the secondary places of entry (46 in total for the seven places, accounting for 26.29% of the total), and the remaining places had very few international athletes.

Last but not least, although the PLA and sports associations are not spatially represented, they belong to the same level of relationship with provincial units in the competition and represent special groups of people. For instance, the PLA represents the military system, the China Avant-Garde Sports Association represents the public security organs and the armed police force system, and the China Locomotive Sports Association represents the Chinese railroad workers system.

Table 3. Global Morani’s I statistics of world-class athletes during 2009–2019.

| Year | Moran’s I | Z   | P    | Year | Moran’s I | Z   | P    |
|------|-----------|-----|------|------|-----------|-----|------|
| 2009 | 0.0369044 | 0.6338 | 0.249 | 2015 | 0.248365 | 0.639 | 0.246 |
| 2010 | 0.106913* | 1.6097 | 0.06  | 2016 | -0.189098** | -1.5838 | 0.04 |
| 2011 | -0.00840335 | 0.3136 | 0.332 | 2017 | 0.26059** | 2.5308 | 0.018 |
| 2012 | -0.329791*** | -2.7573 | 0.001 | 2018 | -0.07085 | -0.3664 | 0.376 |
| 2013 | 0.171772** | 1.829 | 0.038 | 2019 | 0.042143 | 0.6204 | 0.254 |
| 2014 | -0.0158453 | 0.2291 | 0.365 | All years | 0.00283249 | 0.3438 | 0.338 |

Notes:* *: p<0.01, **: p<0.05, *: p<0.1; Excluding China PLA military sports Brigade and professional sports associations.

Table 4. Spatial distribution of World-class Athletes.

| Groups       | Interval/Number of people | Spatial Distribution (Number of people) |
|--------------|---------------------------|----------------------------------------|
| The First    | 91–124                    | Shandong (124); Guangdong (118); Liaoning (110); Jiangsu (99) |
| The Second   | 59–90                     | Heilongjiang (90); Shanghai (83); PLA (82); Zhejiang (77); Beijing (70) |
| The Third    | 35–58                     | Fujian (58); Sichuan (54); Hebei (41); Hunan (41); Hebei (39); Tianjin (35) |
| The Fourth   | 21–34                     | Jilin (30); Henan (26); Guangxi (25) |
| The Fifth    | 6–20                      | Shaanxi (20); Neimenggu (18); Anhui (17); Shanxi (17); Yunnan (17); Xinjiang (13); Guizhou (11) |
| The Sixth    | 5                         | Gansu (5); Jiangxi (5); Chongqing (5); Avant Garde Sports Association (4); Qinghai (3); Hainan (2); Ningxia (2); Locomotive Sports Association (1) |

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| The Fifth    | 6–20                      | Shaanxi (20); Neimenggu (18); Anhui (17); Shanxi (17); Yunnan (17); Xinjiang (13); Guizhou (11) |
| The Sixth    | 5                         | Gansu (5); Jiangxi (5); Chongqing (5); Avant Garde Sports Association (4); Qinghai (3); Hainan (2); Ningxia (2); Locomotive Sports Association (1) |

international talents migrating from the outgoing places are marked in red, and those migrating from the incoming places are marked in black. The migrating group of international athletes in China covers 26 provinces (municipalities and autonomous regions), 21 provinces (municipalities and autonomous regions), the People’s Liberation Army (PLA), and one sports association. From a quantity perspective, there are apparent differences between the migrating and migrating provinces, and the migrating places are more concentrated than the migrating places. The migrating places are mainly distributed and located on the southeast side of the Hu Huanyong Line and the PLA. Among them, Liaoning (33), Shandong (14), Jiangsu (13), Heilongjiang (12), Henan (11), and Hubei (11) are the major emigration places (94 in total for the six places, accounting for 53.71% of the total). Guangdong (9), Hebei (7), Yunnan (7), Anhui (5), Zhejiang (5), and Chongqing (5) are the minor emigration places (38 in total for the six places, accounting for 21.71% of the total), with the rest of the out-migration places having a smaller number of international athletes. PLA (52), Guangdong (22), Beijing (19), and Shandong (14) as the main in-migration places (107 in total for the four places, accounting for 61.14% of the total). Besides, Shanghai (9), Zhejiang (8), Tianjin (7), Liaoning (6), Hunan (6), Shanghai (9), Zhejiang (8), Tianjin (7), Liaoning (6), Hunan (6), Jiangsu (5), and Sichuan (5) are the secondary places of entry (46 in total for the seven places, accounting for 26.29% of the total), and the remaining places had very few international athletes.

Last but not least, although the PLA and sports associations are not spatially represented, they belong to the same level of relationship with provincial units in the competition and represent special groups of people. For instance, the PLA represents the military system, the China Avant-Garde Sports Association represents the public security organs and the armed police force system, and the China Locomotive Sports Association represents the Chinese railroad workers system.

Figure 4. Migration Statistics of World-class Athletes in China.
The formation of areas of origin and destination areas were influenced by the following factors: population, economy, and sports development. Most areas of origin provinces (Guangdong, Shandong, Henan, Jiangsu, Hebei, etc.) are characterized by their dense population. From a statistical perspective, a large population is more likely to lead to a large migrant population. Meanwhile, most immigration areas (Beijing, Tianjin, Guangdong, Shandong, Jiangsu, Zhejiang, etc.) have a rather developed economy, leading to better conditions for athletes, including better payment, social resources, and training. Furthermore, athletes are experiencing more stress from competing in regions that are developed in competitive sports. This means they will participate in the migration to receive more opportunities to attend major sports events. By contrast, professional athletes in less-developed regions will choose to migrate so as to receive better training conditions and resources. A closer look at the destination areas reveals that most are more developed, owing to factors including the need to preserve competitive sports power and the necessity to develop disadvantageous projects. The organization which received the most destinations, in particular, was the PLA, with superiority in training, historical background, political status, and a special competitive system. On the whole, the migration of WCAs resulted from Push-Pull: areas of origin exhibiting Push forces while the destination areas containing the Pull forces.

Figure 5. LISA Aggregation Map of World-class Athletes in China.

Figure 6. Spatial flow path of world-class athletes in China.
3.4.2. The characteristics of the spatial flow

In order to analyze the characteristics of WCAs migration flow, this study created a path map based on migration tracks (See Figure 6) (Note: sports institutions could be listed with their actual locations for mapping and analysis purposes; the map included one route from Shandong to Vanguard Sports Association, which was marked but not part of the analysis.)

A general approach revealed the spatial flow of WCAs to be national and is further categorized into two types. The first type of spatial flow is the flow between provinces, mainly in those provinces located on the Southeast side of the Heihe-Tengchong line. The second type of spatial flow is the flow from provinces to sports associations and the PLA; this study focused on the flow to the PLA.

(1) The path between provinces

This flow type could be distinguished into three layers (See Figure 6a). The first layer consisted of the most prevalent path from Liaoning to Guangdong. The second layer included 21 paths, among them paths such as that from Liaoning to Jiangsu, from Jiangsu to Shandong, and from Yunnan to Guangdong. The third layer contained 62 paths, with examples including from Jilin to Tianjin, from Xinjiang to Shandong, and from Guangxi to Beijing. The different layers displayed a spatial flow featuring several key characteristics: flows were generally based on population size; there existed unidirectional flows from less developed provinces to more developed provinces; some flows were bidirectional and occurred between developed provinces. In general, the majority of migration flow was unidirectional, with a tendency of from North to South and from East to North.

(2) The path from provinces to the PLA

This flow type covered 20 provinces in China (See Figure 6b). Among these, Liaoning, Shandong, and Heilongjiang were the major provinces, followed by Jiangsu, Anhui, Guangdong, Yunnan, and Chongqing. Other less active provinces included Fujian, Henan, and Hubei. The flow was a national phenomenon that focused on Northeast, East, and Southeast China. The unidirectional flow to the PLA can be explained by a number of factors. Firstly, many of these provinces of origin contained a greater number of candidates to choose from. Secondly, the system for training WCAs was based on choosing the best candidates in different levels of sports events, with a flow of “amateur sports institutions → sports institutions → the PLA team → the National team” (Yu et al., 2000). In other words, candidates from more advanced provinces in sports were more likely to be chosen. Third, PLA members enjoyed a special military sports system in China, which means extra opportunities for candidates to receive awards. Last but not the least, Chinese citizens highly respected PLA members, which could be traced back in history.

4. Discussion

Driven by the assessment standards for provincial sports and ample power, the competition among outstanding talents has become even fiercer. WCAs migration has played a crucial role in Chinese provinces’ political, economic, and cultural power. Figure 7 presents the factors and mechanisms influencing WCAs migration based on population migration theories and the Push-Pull theory.

4.1. Individual choices

By examining the data of the careers of WCAs who participated in migration, it is clear that migration was influenced by factors including the population in the area of origin, economy, politics, culture, sports, family, and individual choices. Many individuals experienced a rather tough experience. For instance, Chen Long, a badminton player who is currently residing in Fujian, had experienced a long journey: from his birthplace Jingzhou, Hubei all the way to Fujian, passing Shenzhen, Jingzhou, and Xiamen. Another example is Zhan Tianrui, a taekwondo competitor in Beijing. Her professional career actually began in Yunnan, where she was scouted by the Beijing team coach in 2010 during a match.

According to E.G. Ravenstein’s Law of Migration, migration from the micro perspective has relied on the migrants’ choice of action. Therefore, the cost-benefit for migrants is key to the migrants’ decision, and their action indicates their willingness to take the risks (Li et al., 2019). For WCAs, opportunities to participate, salaries and benefits, their career goals, and the chances of skill transfer and cross projects are all important decision-making criteria.

From the talents’ perspective, both opportunities and challenges exist in their choices. On the one hand, migrating to other regions is a huge change in their lives. By moving, they could receive more professional training and be exposed to more competitions, which further lead them to fulfill their career goals and receive higher payments. On the other hand, migration will bring a series of challenges to talents: adapting to a new environment, coordinating family relations and maintaining emotional health for younger talents, balancing academic performance and training, overcoming the lack of background in the destination areas, transferring athletic skills and techniques, etc. A case study that reflected such challenges was the case of Li Jinyu, a short-track speed skater who moved to Inner Mongolia in 2012. At that time, Li was faced with the problem of having no coach available to train her. Another example was Zhao Jing, a non-professional track and field athlete with a Master's degree in Journalism at Fudan University in Shanghai. She had to pay close attention to her studies regardless of her achievements in competitions. A third notable case study was that of Li Xiaoxia, a table tennis player in Shandong. In her case, she left home to train at Jinan Sports School when she was barely ten years old, and she was the only student who lived in the school's three-story dormitory.

4.2. Influences of areas of origin and destination areas

The Push-Pull theory, introduced by Herberle in 1938, states that migration is the result of factors associated with both areas of origin and destination areas.

The “push factor” of the area of origin includes fierce competition, lack of training environment, family reasons, recommendations from coaches and training bases, and geographical conditions. For instance, table tennis player Ma Long was almost disqualified by the local team in Liaoning. It was due to a coach from Beijing Xicheng Sports School that he was able to continue his career in Beijing. In addition, badminton player Du Pengyu was born in Hebei, but he was sent to Beijing by his father since the local team provided few opportunities. Another example was Chen Dequan, a short-track speed skater born in Liaoning. His career in Jilin was mainly due to his previous coach’s recommendation. From the examples above, the migration of potential WCAs can serve as a solution of competition among talents in areas of origin to a certain extent, and encourages the flow of sports talents. However, it also contributes to a loss of talents in the areas of origin.

On the other hand, the “pull factor” of destination areas includes several benefits: better social resources, better education, more opportunities to be trained by renowned coaches, cross-section recruitment, geographical conditions for training, and the standards of assessing provincial sports and comprehensive power. For instance, rhythmic gymnastics athletes, Bai Xiaoyue, Guo Yuehan, Sun Yanni, and Xu Yanshu were all students of Beijing Sports University, but their hometowns were separate: Liaoning, Hebei, and Heilongjiang. Furthermore, table tennis player Ding Ning left her hometown Heilongjiang to train in Beijing after being scouted by her coach Zhou Shusen. As shown from these examples, the migration of WCAs was able to produce excellent talents either directly or indirectly. Furthermore, talent is essential for destination areas to receive achievements and further develop in competitive sports.

Several additional factors influence migration: self-recommendations and outside recommendations, joint programs with local schools, and
regional flow around provincial games seasons (e.g., rents, exchanges, one-time buyouts, agreements, and contracts) (Yu et al., 2004). For example, table tennis player Fang Bo recommended himself to Shandong Luneng club; Henan-born football player Gu Yasha was recommended to train in Beijing by her PE teacher; and Shanghai-born basketball player Shao Ting studied at Beijing Normal University and competed in Sichuan due to the joint contract in her university.

4.3. The effects of migration on Chinese sports

As discussed, migration is generally the result of differences between regional population sand geographical environments, the development of PLA sports, and the imbalance between provincial economics, and political and cultural development. Provinces with larger populations usually experience the case of supply over demand in the case of WCAs. In other words, certain WCAs with huge potential will choose to migrate to other regions when they are still children. Differences in the geographical environment would lead to the phenomenon of migration due to the need of talents move to provinces that are more suitable for training. This can be seen in the example of Jiangsu-born Qi Guangpu, a professional freestyle skiing athlete who moved to Changchun, Jilin Province and joined as a member of the local freestyle aerial team at the age of 10. The provinces that are more developed in economy, politics, and culture, with their large amount of investment, tend to attract more WCAs and potential talents. It is easy to see that migration has benefited Chinese sport by producing more talents to contribute to China’s goal of becoming a world sports power. WCAs migrant Olympic winners include table tennis champions Li et al. (2019), Ding Ning (2016), and Ma Long (2012 and 2016); badminton champion Chen Long (2016); and short track speed champion Wu et al. (2018 Winter).

Furthermore, the migration to the PLA boosted the number of WCAs in China as well as the overall power of the PLA. For instance, during the 7th CISM Military World Games, China won 133 gold medals, and broke seven world records, and had 85 CISM records. The outstanding performance was further praised by Chinese President Xi Jinping, hoping that the guests could take this opportunity to learn about China and the Chinese military in the new era and feel the hospitality and friendliness of the Chinese people.

5. Conclusions and further prospects

6. Conclusion

This research paper examines the basic features, spatial distribution, and spatial evolution of Chinese WCAs between 2009 and 2019 from the perspective of sports geography. The paper further analyzes the

Figure 7. Formation and influence mechanism of world-class athletes’ migration.
formation and changes of WCAs migration from the subjects, areas of origin, and destination areas using migration theory and the Push-Pull theory. The paper concludes:

(1) There is a vast difference between participant demographics across different events, including age and gender. From a temporal approach, the changes appeared in the form of three peaks and two troughs, with individual trends displaying both inverted U and inverted V shapes. The average age of WCAs was 23.18.

(2) The spatial distribution displayed obvious diversity and appeared to be concentrated in the southeast of the Heihe-Tengchong line. The direction indicated was from Northeast to Southwest with a positive correlation. From a spatial approach, the distribution exhibited “high-high” and “low-low” features. However, the features of geographical proximity and spatial heterogeneity were not apparent.

(3) Liaoning, Shandong, Jiangsu, Heilongjiang, Henan, and Hubei were the major places of origin, while the places of destination were primarily located in Southeast China and the PLA.

(4) From a nationwide perspective, migrations can be classified into two types. One is the regional migration that shares the features below: one-way flows from less populated and developed regions to more developed regions; bidirectional flows between developed regions in sports; one-way flows from regions that are less developed in sports to those that are more developed. The other is the migration from provinces to the PLA or sports associations, with the areas of origin mainly located in Northeast, East and Southwest China.

(5) Fierce competition, poor training condition, unsuitable climate, family factors, recommendations from coaches and training grounds, and unsuitable location act as Push factors for migration. Social resources, education, talent scouting, training facilities, trans-event recruitment, skill transfer, suitable geographical environment, the assessment of provincial sports, and comprehensive power are the Pull factors.

(6) Overall, migration is generally the result of the difference between regional population and geographical environment, the development of PLA sports, and the imbalance between provincial economics, and political and cultural development.

6.1. Further prospects

From the study of the basic features and spatial distribution of WCAs, as well as the research of the patterns of spatial-evolution and factors that affect migration, here are five solutions that are derived from the research in terms of training more WCAs. (1) Develop more training for male athletes, especially programs on skill-dominated same-field competition events and combative sports. Furthermore, with hosting the Beijing Winter Olympic Game, training in Winter sports is also necessary. (2) Promote the juvenile three-tier training system, enhance the establishment of primary and secondary compound training systems, as well as develop a broader approach to perfecting the whole system to train and select better professional athletes. (3) Further discover the migration patterns of WCAs and apply them to leading juvenile athletes to train in various regions and programs. (4) Implement further projects which emphasize major sports events. Furthermore, regional culture, as well as regional features, should be taken into consideration as crucial factors in developing regional sports projects and building a social understanding of competitive sports training. (5) National teams should serve as a tie between different provinces and they are encouraged to compete against one another in teams. This collaboration not only serves as a training opportunity for individuals to prepare for the Olympic Games, but also lays the foundation of teamwork between sports universities, educational institutions and national training bases in terms of training athletes.

To summarize, under the influence of the national strategy regarding sports development, WCAs migration will become a more common trend which will involve athletes choosing to train either in different regions or in different fields. Furthermore, the migration will demonstrate more regional features and a better system of selecting and training WCAs. By studying and comparing the research with other similar studies of regional sports development and evolution worldwide, the research will surely contribute to China’s future sports projects. Furthermore, the paper will also serve as an introduction to various methodologies, including but not limited to approaches of online and survey data analysis, cultural geography, time geography, emotional geography, life course theory, and social network analysis to further analyze the features of migration. Future studies on the evolution patterns, migration features, demographical features, individual development and social network changes can reflect in detail how the factors can be examined diversely. In addition, social events and major problems can also be analyzed from the perspective of sports geography and should be regarded as a major direction of China's sustainable sports development.

Declarations

Author contribution statement

Jinlong Shi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Gang Li: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.

Shuyan Xue: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Qifan Nie: Contributed reagents, materials, analysis tools or data.

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Declaration of interest’s statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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