



Research Article

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Chinese sporting population development research based on the logistic growth curve

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ABSTRACT

This text makes an analysis on the aging structure, gender characteristic, culture feature and the difference among urban and suburb of different areas. It points out that the age of Chinese Sporting population mainly ranges from 16~45 nowadays and most of people are college and high school students, providing the situation where there are more sportspeople in the mid-eastern parts and less in the western parts, for the influence of economy. Next, correlation analysis methods were used to make the quantitative analysis on the relativity of the population and economic factors in different sporting systems. And then, in order to predict the population, we compare the Pearson correlation coefficient and choose the more correlative one to analyze. For the last step, we can take advantage of the Logistic Growth Curve to build a model of sporting system population prediction and obtain the prediction mathematical equations through investigating the historical statistics from those vocational sporting colleges, sporting schools and a vocational sporting schools filtered by the correlational analysis method. From this step, we can predict the changes of the population attending the three kinds of schools in the five years to follow after the year of 2012. Furthermore, we can draw the conclusion that in the five years to follow after 2012, there will be more people attending vocational sporting college and sporting school but less people in avocational sporting school.

Keywords: Sport Population, Correlation analysis, the Pearson correlation coefficient, the Logistic Growth Curve

INTRODUCTION

To assess whether or not a country is prosperous, the developing of its sporting vocation is one of the standards. And the developing of the sporting population is the crucial factor for developing sporting vocation. Since China declared its independence, sports have been taken seriously and people's enthusiasm for sports becomes stronger and stronger for the sake of the impact of the nationwide fitness program. As Chinese sporting population grows, there have been considerable scholars who investigate the developing of Chinese sporting population until now.

Taking the present social structure in China into consideration and consulting large amounts of documents, Xiao Huan yu analyzed the basic features of Chinese sporting population and its inevitable connection with the social structure in the investigation towards Chinese sporting population. He raised the view that sporting population is a part of society and its developing is bound to be influenced by the developing of society, so it is necessary to take social factors into consideration when investigating sporting population; In the investigation of sporting population, Fang Li classified the sporting population by analyzing the fundamental definition of it and provided the statistics standard of sporting population; When studying the theory of sporting people, He Jian wen stated the basic features and definition of sporting population comprehensively. Furthermore, he combined previous research findings to improve his and acquired the comprehensive statement of sporting population theory; When Pang Yuan yu studied the accurate Chinese sporting population, through analyzing the basic features of sporting population and considering the contemporary situation in China, he pointed out the developing direction of Chinese sporting population in the future; Miao Zhi wen made a profound research on the structure of Chinese sporting people in the analysis of Chinese contemporary sporting population and provided a new structure of Chinese sporting population

according to the present social development and sociological theory.

This text makes an analysis on the aging structure, gender characteristic, culture feature and the difference among urban and suburb of different areas. It points out that the age of Chinese Sporting population mainly ranges from 16~45 nowadays and most of people are college and high school students, providing the situation where there are more sportspeople in the mid-eastern parts and less in the western parts, for the influence of economy. Next, correlational analysis methods were used to make the quantitative analysis on the relativity of the population and economic factors in different sporting systems. And then, in order to predict the population, we compare the Pearson correlation coefficient and choose the more correlative one to analyze. For the last step, we can take advantage of the Logistic Growth Curve to build a model of sporting system population prediction and obtain the prediction mathematical equations through investigating the historical statistics from those vocational sporting colleges, sporting schools and avocational sporting schools filtered by the correlational analysis method. From this step, we can predict the changes of the population attending the three kinds of schools in the five years to follow after the year of 2012.

Model construction

Sporting population is the fundament and motive power of the development of Chinese sporting vocation. Studying the aging structure, gender structure and culture structure of sporting population can be of help to make further analysis about the recent condition of sporting population. At the same time, we can find and solve problems during this process.

2.1 The basic features of Chinese sporting population

2.1.1 The aging structure of Chinese sporting population

The slogan "Sports can strengthen a country" has been widely spread since China declared its independence and China has realized the slogan relatively well. People's enthusiasm for sports becomes stronger and stronger and the sporting population successfully makes its augmentation. "Everybody does sports" is no longer an empty word. In daily life, exercisers are ubiquitous. If you want to learn the situation of Chinese sports, the best way is to learn the aging distribution of sporting population. Figure1 is Our country sports population age structure. The statistics are from the yearbook of Chinese statistics, State Physical Culture Administration and Internet investigations, etc.

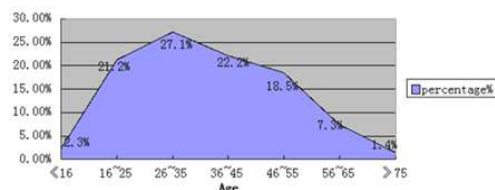


Figure 1: Our country sports population age structure

From Figure1 we can know that the aging distribution of Chinese sporting population ranges mainly from 16~45, then 46~55. People who are under 16 and over 55 do fewer sports relatively. The reason why the distribution characteristic is like that is influenced mainly by culture level, physical quality and spirit, etc. People of 16~45 years old are mainly young and middle-aged, so doing sports is a must during their spare time. People who are under 16 and over 55 are mainly children and old. Doing sports is a little bit risky no matter from the internal factor for the aspect of physical quality or the external factor of the security of sporting facilities. As a result, they do less exercise relatively. Consequently, the sporting population of this age group is less.

In order to encourage people who are under 16 and over 55 to do sports, the government should strengthen the construction of sporting facilities to guarantee the security. People of this age group should enhance their sporting spirit and in this way, they can raise the quality of body and life.

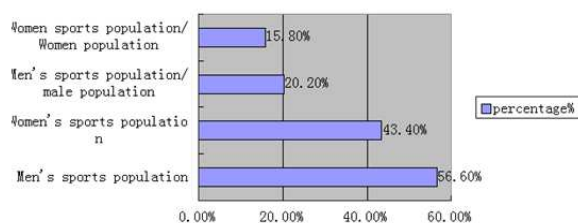
2.1.2 The gender structure of Chinese sporting population

Gender issues are important issues we must face in the development of Chinese sporting cause. Through investigating gender issues, we can analyze the degree of cognition and participation towards sports from different gender in people groups. From the aspect of gender, we can reform the sporting system and construct suitable sporting facilities for people groups in different gender to raise people's enthusiasm for sports. In this way, the sustainable development of Chinese sporting cause is promoted. Table1 shows some details from the sex ratio of sporting population. The statistics are from the yearbook of Chinese statistics, State Physical Culture Administration and Internet investigations, etc.

Table 1: The sex ratio of sporting population

| Classification | Sporting population | | Male sporting population/ Male population | Female sporting population/ Female population |
|----------------|---------------------|--------|---|---|
| | male | female | | |
| Percentage | 56.6% | 43.4% | 20.2% | 15.8% |

Consequently, in order to analyze the degree of cognition and participation towards sports from people group of different gender, the statistics above was made into Figure2 to get further analysis and conclusion:

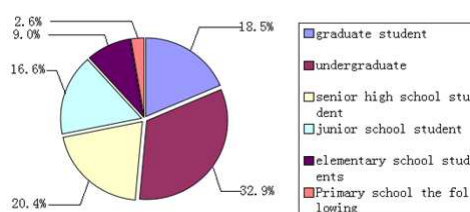
**Figure 2: Sports population sex ratio is a bar chart**

From this bar chart we can see that, in Chinese sports population, men are in a larger group, in 56.6 percent. The rate of men's sports population and male population are larger than the rate of women's sports population and women population, which is to say, men attach more importance to sports than women and the passion of men to learn and participate in sports is higher than women. This phenomenon is more obvious in Chinese sports. Male athletes are in a large quantity in some big sport events like football, basketball while female athletes majoring in some sports like aerobics and lala gym. When we analyze the reason we find that it is because the restriction from the idea of the traditional culture and the physical factors of women which makes the women's development in the sports circle restrict in some degree.

2.1.3 The cultural structure of Chinese sports population

Cultural level is the most important thing which influences the level of a person even a nation's consciousness. As for the development of sport, the cultural level of the sports population therefore influences their sport consciousness, and thus influences the development of sport. Different cultural groups have different faith and different cognition towards sport. Studying the characteristic of cultural structure of the sport population is beneficial to find the existing problems in the development of the Chinese sport. After we find the problems, we can work out solutions to the sport population in different cultural levels.

So in order to analyze the cultural structure of Chinese sport population, we look up plenty of statistics from the Chinese statistical yearbook, the reports of State Physical Culture Administration and the internet, we draw a pie chart like Figure 3, and after the analysis we come to this conclusion:

**Figure 3: Our country sports population structure of culture**

From this pie chart Figure 3 we can see that among the Chinese sport population, the undergraduate and senior high school student are both in a large proportion and the graduate student, junior school student and elementary school student are in a smaller proportion, while the primary school the following only take a proportion of 2.6 percent. This phenomenon shows that the whole cultural level of Chinese sport population is comparatively high especially in the Chinese degrade athletes. At present, the number of Chinese national athletes and international athletes is growing which shows that the cultural quality if Chinese sport population is higher and Chinese sport career is developing towards a high level.

2.1.4 The region feature of the Chinese sport population

With the different development levels in different areas, the Chinese sport population have obvious region feature. The analysis of the region feature of the sport population which mainly includes the difference among the East, the

Middle and the West and also the sport population gap caused by the urban-rural gap is beneficial for us to take different sport development policies according to different region features, and thus makes the Chinese sport career develop in the whole country. Table 2 is the basic information of the region feature of the Chinese sport population and the percentage refers to the sport population accounts for the total population. The statistic is coming from the Chinese statistical yearbook, the reports of State Physical Culture Administration and the internet and etc.

Table 2: The region feature of the sport population

| | Region | | | Urban and Rural | |
|-------------|--------|--------|------|-----------------|---------|
| | East | Middle | West | Urban | Country |
| percentage% | 21.5% | 21.4% | 8.1 | 28.9% | 12.4% |

According to the analysis of the statistics in the chart, we come to the conclusion:

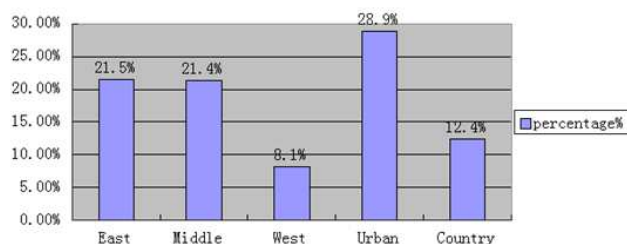


Figure 4: Sports population of the area

From this histogram Figure4, we can see: as for the area distribution, the Chinese sport population has a character of “more people in the Middle and the East, less people in the West”. As for the urban-rural distribution, there is more sport population in the country, about 28.9percent, while in the country there is only 12.4percent. This is mainly influenced by the development of the area economy and the traditional culture, which makes the slow developing areas’ sport career, develop relatively slow. In the meantime, this shows that the development of the sport population is closely related to the degree of the development of the society’s economy.

2.2 The analysis of the Chinese sport population based on the correlation analysis

Based on the research of the basic information about the Chinese sport population, the Chinese sport population has a close connection with the development of the society’s economy. While in China, there are many forms of sport population which mainly includes Professional, Sport Institute of Technology, Sports School, Competitive Sports School, Amateur Sports School, and Single Sports School and so on. We come to the further analysis of the connection between the varying number of people and the economy based on the sport population in these organizations. Table 3 shows the

Table 3 is a chart about the varying number of people in sports system in China between 2008~2012. The statistics come from the China Statistical Yearbook:

Table 3: The statistics of population to different sports system

| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|-------|-------|-------|-------|-------|
| Per capita GDP (Yuan) | 23708 | 25608 | 30015 | 35198 | 38420 |
| Professional, Sport Institute of Technology | 2988 | 3056 | 3480 | 4671 | 6126 |
| Sports School | 15797 | 15870 | 15971 | 16912 | 16305 |
| Competitive Sports School | 389 | 476 | 486 | 323 | 398 |
| Amateur Sports School | 25897 | 24571 | 24392 | 24169 | 21657 |
| Single Sports School | 357 | 348 | 330 | 371 | 316 |
| Training Base | 3743 | 3875 | 3927 | 3323 | 3892 |
| Stadium | 15579 | 15398 | 15776 | 16315 | 14993 |

1.2.1 The guiding ideology of the related analysis

The method is to conduct correlation analysis to the two or more correlative variable factors.

To related analysis request every factors are related or comparable, the range contains almost every parts of our life. Pearson correlation coefficient is one of the related analyses, and it use for showing statistics between two variables, and for ration calculation of the similarity between two variables. And the formula is as follows:

$$\rho(X, Y) = \frac{\text{cov}(X, Y)}{\sigma_x \sigma_y} = \frac{E((X - \mu_x)(Y - \mu_y))}{\sigma_x \sigma_y}$$

$$\mu_x = E(X), \sigma_x^2 = E(X - \mu_x)^2 = E(X^2) - E^2(X)$$

So, Pearson correlation coefficient can be also write as:

$$\rho(X, Y) = \frac{E(XY) - E(X)E(Y)}{\sqrt{E(X^2) - E^2(X)}\sqrt{E(Y^2) - E^2(Y)}}$$

When two variables' Pearson correlation coefficient go near to 1 or -1, the two variables are related in most parts or closely. When it approaches to 1, means the two variables positive correlation, and on the contrary, when it approaches to -1, means the two variables negative correlation.

2.2.2 Data processing and results

In the study of sports system population, we make the sports system populations as an observable variable, and build the correlation coefficient formula between sports system populations and GDP of per capita. We use SPSS to dispose the data in the form, and get the result of Table 4:

Table 4: The pertinence of coefficient

| Control variable | | Professional sport skill school | Sports school | Competitive sports school | Amateur sports school | Unidirectional sports school | Training base | gym |
|-------------------|---------------------------------|---------------------------------|---------------|---------------------------|-----------------------|------------------------------|---------------|-------|
| GDP of per capita | Pearson correlation coefficient | .953* | .759 | -.43 | -.878 | -.362 | -.24 | -.034 |
| | significance (both sides) | .012 | .137 | .469 | .050 | .549 | .690 | .957 |

We can conclude from Table 4 that in seven physical education system institutions, Professional sport skill school, Amateur sports school and Sports school have the most pertinence with GDP of per capita. It established the prediction to the sports system institutions population in the next step.

2.3 The prediction to the sports system institutions population based on Logistic Curve

Based on the analyses that mentioned above, we choose the most effected sports system institution (Professional sport skill school, Amateur sports school and Sports school) to predict its population. We can predict the population between 2013 and 2017 by Logistic Curve.

2.3.1 The guiding ideology of Logistic Curve

The diversification velocity of things in different period are not the same. The sports system institutions population of China diversification uncertainty in the process of time. We adhibit Logistic Curve here that it have extensive use in representing these kinds of uncertainty development tendency questions.

The usual mathematical model of Logistic Curve is:

$$\frac{dy}{dt} = ry(1 - \frac{y}{L}) \quad (1)$$

Y is the predict value, L is its limit value, r is increase constant, and $r > 0$.

Solve the equations we can get:

$$y = \frac{L}{1 + ce^{-rt}} \quad (2)$$

Mark the usual form of Logistic Curve as:

$$y_t = \frac{1}{K + ab^t}, K > 0, a > 0, 0 < b \neq 1 \quad (3)$$

The estimate of the parameter in Logistic Curve goes to $y_t' = \frac{1}{y_t}$, as:

$$y_t' = K + ab^t \quad (4)$$

Trisect n observed values in time series, it have m terms in every part, as $n = 3m$.

Part one: $y_1, y_2, y_3, \dots, y_m$

Part two: $y_{m+1}, y_{m+2}, y_{m+3}, \dots, y_{2m}$

Part three: $y_{2m+1}, y_{2m+2}, y_{2m+3}, \dots, y_{3m}$

In this, the sum of trend in every parts is equal to the relevant sum of observed values, so we get the parameter estimate, the trinity method steps as follows:

Mark each part of the sum of observed values as:

$$S_1 = \sum_{t=1}^m y'_t, S_2 = \sum_{t=m+1}^{2m} y'_t, S_3 = \sum_{t=2m+1}^{3m} y'_t, \quad (5)$$

With:

$$\left\{ \begin{array}{l} S_1 = \sum_{t=1}^m \hat{y}_t = \sum_{t=1}^m (K + ab^t) = mK + ab(1 + b + b^2 + \dots + b^{m-1}) \\ S_2 = \sum_{t=m+1}^{2m} \hat{y}_t = \sum_{t=m+1}^{2m} (K + ab^t) = mK + ab^{m+1}(1 + b + b^2 + \dots + b^{m-1}) \\ S_3 = \sum_{t=2m+1}^{3m} \hat{y}_t = \sum_{t=2m+1}^{3m} (K + ab^t) = mK + ab^{2m+1}(1 + b + b^2 + \dots + b^{m-1}) \end{array} \right. \quad (6)$$

$$(1 + b + b^2 + \dots + b^{m-1})(b-1) = b^m - 1$$

Then:

$$\left\{ \begin{array}{l} S_1 = mK + ab \frac{b^{m-1}}{b-1} \\ S_2 = mK + ab^{m+1} \frac{b^{m-1}}{b-1} \\ S_3 = mK + ab^{2m+1} \frac{b^{m-1}}{b-1} \end{array} \right. \quad (7)$$

So get the result:

$$\left\{ \begin{array}{l} b = \left(\frac{S_3 - S_2}{S_2 - S_1} \right)^{\frac{1}{m}} \\ a = (S_2 - S_1) \frac{b-1}{b(b^m - 1)^2} \\ K = \frac{1}{m} \left[S_1 - \frac{ab(b^m - 1)}{(b-1)} \right] \end{array} \right. \quad (8)$$

In addition, when predict the data; we should inspect it with following method:

$$\frac{y_{t+1} - y_t}{y_t - y_{t-1}} \approx b \quad (9)$$

2.3.2 Data processing of Logistic Curve and conclusion

From $y_t' = \frac{1}{y_t}$ we can get the changed data of 2008~2012 in Table 5:

Table 5: Data form changed by Logistic Curve

| Year | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---------------------------------|--------|--------|--------|--------|--------|--------|
| Professional sport skill school | 0.347 | 0.335 | 0.327 | 0.287 | 0.214 | 0.163 |
| Sports school | 0.0641 | 0.0633 | 0.0630 | 0.0626 | 0.0591 | 0.0613 |
| Amateur sports school | 0.0392 | 0.0386 | 0.0407 | 0.0410 | 0.0414 | 0.0462 |

By (5) we get: $S^1_1 = 0.682, S^1_2 = 0.614, S^1_3 = 0.377$

$$S^2_1 = 0.1274, S^2_2 = 0.1256, S^2_3 = 0.1204$$

$$S^3_1 = 0.0778, S^3_2 = 0.0817, S^3_3 = 0.0876$$

By (8) we get: $b^1 = 1.867, a^1 = -0.005111, K^1 = 0.35468$

$$b^2 = 1.6999, a^2 = -0.0001453, K^2 = 0.1281$$

$$b^3 = 1.5128, a^3 = 0.000796, K^3 = 0.0748$$

So, the Logistic Curve mathematical model of sports system institutions population is:

$$\begin{cases} y^1_t = \frac{1}{0.35468 - 0.005111 \times 1.867^t} \\ y^2_t = \frac{1}{0.1281 - 0.0001453 \times 1.6999^t} \\ y^3_t = \frac{1}{0.0748 + 0.000796 \times 1.5128^t} \end{cases}$$

When we predict sports system institutions population of China in 5 years after 2012, we can substitution value t into the formula above. If we predict y_{2013} , then we get $t = 2013 - 2004 + 1 = 10$ and the result in Table 6:

Table 6: Prediction of sports system institutions population of China

| | 2013 | 2014 | 2015 | 2016 | 2017 |
|---------------------------------|-------|-------|-------|-------|-------|
| Professional sport skill school | 6135 | 6219 | 6258 | 6301 | 6325 |
| Sports school | 16413 | 16525 | 16797 | 17105 | 17297 |
| Amateur sports school | 21579 | 20681 | 20432 | 19837 | 19693 |

We draw the population prediction above to the broken line in Figure 5 for the better analyze of trend in sports system institutions:

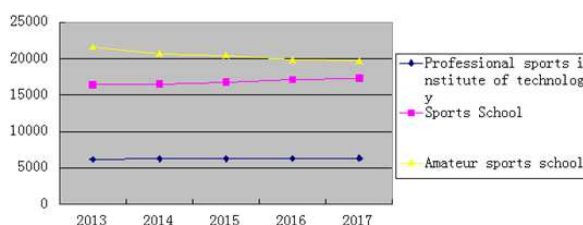


Figure 5: The number of sports system institutions

Through the analysis to the statistics of broken line Figure 5 above, we can make the conclusion of: population of Professional sport skill school have increased in 5 years after 2012, but the population of Amateur sports school reduced to a certain extent. As a whole, population of Amateur sports school is in the majority, but in a trend of descend. They should take some actions like strength the publicity of sports, reform manage system, perfect the facility of sport to keep the population of Amateur sports school.

CONCLUSION

(1) This essay firstly analyzed the basic condition of Chinese sports population. It mainly including the age structure, gender character, culture character, and differences among different zones of sports population. So that we conclude that: the majority of Chinese sports population is in the age from 16 to 45, and most of them are students in senior high school and college. And with the effect of economic development, it appears more in the East than the West, it is more distinctness between the city and the countryside.

(2) Based on the analysis of the basic information of sports population, we used correlational analysis method to analyze correlation of different sports system population and economic factor in a ration. In compare of Pearson correlation coefficient, we chose the most effected ones (Professional sport skill school, Amateur sports school and Sports school) to predict the population by economy.

(3) We use the Logistic Curve method to build the model of prediction of sports system population. Through the analysis of historical data of Professional sport skill school, Amateur sports school and Sports school in 2007-2012, we get the predict formula, and predict the changes in population in 5 years after 2012. In that we concluded, population of Professional sport skill school have increased in 5 years after 2012, but the population of Amateur sports school reduced to a certain extent.

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