

## VISUALIZED ANALYSIS OF HOTSPOT ISSUES OF TABLE TENNIS BASED ON THE PROSPECTIVE OF VOSVIEWER

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**Abstract. Aim.** This paper deals with the most important issues of table tennis to analyze the distribution of the main fields, authors, and institutions related to table tennis in China and optimize its study. **Materials and methods.** Data source. The data is downloaded from the China National Knowledge Infrastructure (CNKI), and 16 types of sports core journals (released in 2021) are selected from CNKI. It is retrieved with the keyword “table tennis”. The papers on table tennis searched from CNKI are from January 2001 to December 2020, with a time span of 20 years. There is a screening of the literature to retrieve 677 of them published in the domestic sports core journals. Study process. The data obtained was processed with the statistical tool Excel and the visual analysis tool VOSviewer. **Results.** Reliable data were obtained from the rating of sports journals in terms of the volume of publications, current research topics, authors, and the issues under study in general. **Conclusion.** The colleges and universities are the most important battlefield for the analysis and study of table tennis sport, and the core institutions are Beijing Sport University, Shanghai University of Sport and so on. The study outcomes are featured with a significant regional difference. There are abundant outcomes in Beijing and Shanghai, but it is almost a blank in the central and western regions.

**Keywords:** Table tennis, VOSviewer, Visualized analysis, China, tennis sport

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## ВИЗУАЛЬНЫЙ АНАЛИЗ АКТУАЛЬНЫХ ПРОБЛЕМ НАСТОЛЬНОГО ТЕННИСА С ИСПОЛЬЗОВАНИЕМ ИНСТРУМЕНТА VOSVIEWER

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**Аннотация. Цель.** Настоящая статья посвящена наиболее важным вопросам настольного тенниса, в том числе анализу распределения основных тенденций, авторов и учреждений, связанных с настольным теннисом в Китае, а также оптимизации изучения этого вида спорта. **Материалы и методы.** Источник данных. Сведения загружены из БД Китайская национальная инфраструктура знаний (CNKI), выбраны 16 ключевых спортивных журналов на 2021 год. Искомая информация извлечена по ключевому словосочетанию «настольный теннис». Документы по настольному теннису, найденные в CNKI, относятся к периоду протяженностью 20 лет (с января 2001 г. по декабрь 2020 г.). Из всей литературы отобраны 677 источников, опубликованных преимущественно в китайских спортивных журналах. Статистический анализ проводили с использованием инструмента Excel и

инструмента визуального анализа VOSviewer. **Результаты.** С использованием рейтинга спортивных журналов получили достоверные данные по объему публикаций, актуальной тематике исследований, авторам и проблемам изучения настольного тенниса в целом. **Заключение.** Колледжи и университеты являются наиболее важными учреждениями с точки зрения анализа и исследования настольного тенниса, а лидерами среди них выступают Пекинский спортивный университет, Шанхайский университет спорта и так далее. По результатам исследования выявили значительные региональные различия со смещением акцентов в сторону Пекина и Шанхая при практически полном отсутствии данных из центральных и западных регионов.

**Ключевые слова:** настольный теннис, VOSviewer, визуальный анализ, Китай, теннис

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The table tennis sport is an advantageous sport in China. In the past few years, foreign and domestic scholars have concluded and summarized the study outcomes in the field of table tennis from the perspectives of technical and tactical analysis methods, scientific training, reserve talent training mode, psychological characteristics, the origin of table tennis projects, and the promotion and dissemination of table tennis sports. Along with the ceaseless development and progress of table tennis techniques, the domestic scholars also study visualization technology for the literature of table tennis in all aspects. By far, the application of the knowledge graph tool is related to the visualization process of research direction and development trends in specific professional fields, which has been a new trend in literature research and knowledge service. The paper uses the literature on table tennis adopted in the CNKI database as study objects to have

a statistical analysis of the literature on table tennis with the statistical tool Excel and the visual analysis tool VOSviewer. And then the most important and hotspot issues would be analyzed with a knowledge graph so as to analyze the main fields, authors, and institution distribution of the study of table tennis sport in China, which would provide a reference to optimize the study of domestic table tennis sport in China.

#### Study results and analysis

Analysis of the proportion of articles published in journals of table tennis sport in China. The distribution of literature sources shows that 677 papers are retrieved from 16 sports core journals, such as the Journal of Beijing Sport University.

Seen from table 1, we could see that the journal with the highest publication volume is *Journal of Beijing Sport University*, 96 with the proportion of 14.18%; and it is followed by *Sports*

Table 1

Statistical Chart of Papers on Table Tennis

| Serial Number | Journal Name   | Publication Volume | Percentage |
|---------------|--|--------------------|------------|
| 1             | Journal of Beijing Sport University                            | 96                 | 14.18%     |
| 2             | Sports Culture Guide   | 71                 | 10.49%     |
| 3             | Journal of Shenyang Sport University                           | 69                 | 10.19%     |
| 4             | China Sport Science and Technology                             | 58                 | 8.57%      |
| 5             | Journal of Tianjin University of Sport                         | 56                 | 8.27%      |
| 6             | Journal of Wuhan Institute of Physical Education               | 55                 | 8.12%      |
| 7             | Journal of Shanghai University of Sport                        | 37                 | 5.47%      |
| 8             | Journal of Shandong Sport University                           | 34                 | 5.02%      |
| 9             | Journal of Guangzhou Sport University                          | 32                 | 4.73%      |
| 10            | Journal of Physical Education                                  | 31                 | 4.58%      |
| 11            | Journal of Nanjing Sport Institute                             | 30                 | 4.43%      |
| 12            | Journal of Chengdu Sport University                            | 26                 | 3.84%      |
| 13            | China Sport Science  | 25                 | 3.69%      |
| 14            | Journal of Xi'an Institute of Physical Education               | 24                 | 3.55%      |
| 15            | Journal of Capital University of Physical Education and Sports | 19                 | 2.81%      |
| 16            | Sports & Science   | 14                 | 2.07%      |

*Culture Guide*, 71 with the proportion of 10.49%. The third one is *Journal of Shenyang Sport University*, 69 with the proportion of 10.19%. There are 58 in *China Sport Science and Technology* with the proportion of 8.57%; 56 in *Journal of Tianjin University of Sport* with the proportion of 8.27%; 55 in *Journal of Wuhan Institute of Physical Education* with the proportion of 8.12%; 37 in *Journal of Shanghai University of Sport* with the proportion of 5.47%; 34 in *Journal of Shandong Sport University* with the proportion of 5.02%; 32 in *Journal of Guangzhou Sport University* with the proportion of 4.73%; 31 in *Journal of Physical Education* with the proportion of 4.58%; 30 in *Journal of Nanjing Sport Institute* with the proportion of 4.43%; 26 in *Journal of Chengdu Sport University* with the proportion of 3.84%; 25 in *China Sport Science* with the proportion of 3.69%; 24 in *Journal of Xi'an Institute of Physical Education* with the proportion of 3.55%; 19 in *Journal of Capital University of Physical Education and Sports* with the proportion of 2.81%; 14 in *Sports & Science* with the proportion of 2.07%. *Journal of Beijing Sport University*, *Sports Culture Guide* and *Journal of Shenyang Sport University* are the main journals to publish the literature on table tennis, which include 236 papers, accounting for 34.86% of the total.

We could see that the publication volume of all major Chinese sports core journals is imbalanced, and there is a deviation in the emphasis on scientific research in table tennis. Certainly, all major Chinese sports core journals have different focuses in the selection of publication papers, and the focus on the selection is shown in the imbalanced tendency in the number of published papers [4]. The *Journal of Beijing Sport University* accounts for the highest proportion,

14%. Beijing Sport University is the only sports university in China, and its comprehensive schooling level is in a leading position among other sports colleges and universities. The university attaches the highest importance to the scientific research and publication of table tennis. The publication volumes of *Sports Culture Guide* and *Journal of Shenyang Sport University* are similar, accounting for 10%. The publication volumes of *China Sport Science and Technology*, *Journal of Tianjin University of Sport*, and *Journal of Wuhan Institute of Physical Education* are similar, accounting for 8%. The publication volumes of *Journal of Shanghai University of Sport*, *Journal of Shandong Sport University*, *Journal of Guangzhou Sport University* and *Journal of Physical Education* account for 5%. The publication volumes of *Journal of Nanjing Sport Institute*, *Journal of Chengdu Sport University*, *China Sport Science* and *Journal of Xi'an Institute of Physical Education* are in the proportion of 4%. The proportions of *Journal of Capital University of Physical Education and Sports* and *Sports & Science* are 3% and 2%, respectively.

Seen from the publication volume of all major Chinese sports core journals, the *Journal of Beijing Sport University* must be the core area of analysis and research in table tennis with a publication volume of 96, which shows that its scientific research force matches its economy and culture. The journal has made an outstanding contribution to the prosperity and development of analysis in the field of table tennis; however, it also reflects the insufficiency of other areas in the field from the opposite direction [11]. It is suggested that the scientific research institutions in Beijing should carry out a cooperative study with other institutions in other areas so that much more scientific research institutions could parti-

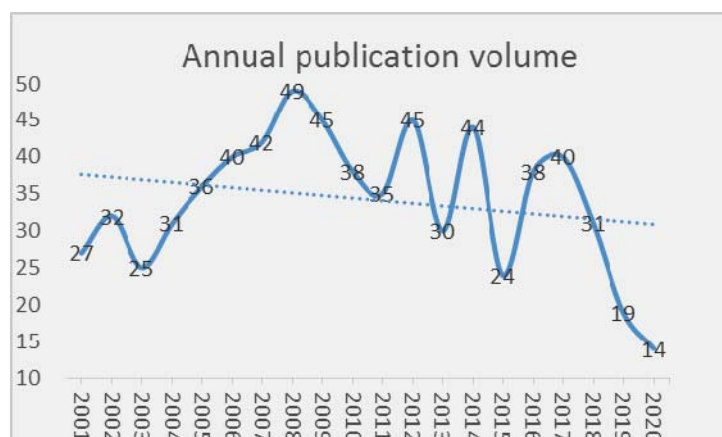


Fig. 1. Annual distribution of academic papers about table tennis

participate in the scientific research projects and to be a better promoter of the comprehensive development of the analysis and study of table tennis.

Analysis of the annual publication volume of study papers on table tennis in China. The annual publication volume of papers about table tennis in China shows the development of the study field to some extent, so as to lay a foundation for the study. The annual volume of academic papers in the field is shown in Fig. 1.

The trend change shown in the annual publication volume of academic papers on table tennis, along with passing time, is of great significance to the description of previous developments and the future prediction of the field [4]. As seen from Fig. 1, the publication volume of literature has certain differences during various periods. From the figure, it could be judged that the general tendency is decreasing. The publication volumes in 2001, 2002, and 2003 were 27, 32, and 25, which is relatively stable. However, the volume had been increasing annually from 2003 to 2008, the year of the Beijing Olympic Games, which should be closely related to the opening of the Olympic Games in Beijing. Then, the publication volume had been decreased annually for the closing of the Olympic Games in 2008, and it was decreased to 35 in 2011. However, the publication volume was still higher than before 2005. It surged to 45 in 2012, the Olympic Games in London, which is second to that of the year of the Beijing Olympic Games. There was an unstable period with the law from 2013 to 2017. The year 2013 was a low-peak period after the London Olympic Games, with a publication volume of 30. In 2014, the reform of table tennis to use balls made of new materials would impose a huge impact on the pattern and the future development of table tennis, so there was a bigger publication volume, second only to 2008, 2009, and 2012 with a publication volume of 44. There was a decline in 2015, with an annual publication volume of 24, the lowest since 2001. The publication volumes in 2016, Rio Olympic Games, and 2017, post-Olympic Games, rose back to 38 and 40, respectively, and decreased annually from 2018 to 2020. There are so many reasons. The General Plan of Chinese Football Reform and Development, the Notice on Printing and Distributing the Medium- and Long-Term Development Plan of Chinese Football (2016–2050), and the Ice and Snow Sports Development Plan (2016–2025) released in 2015 mean that our country has put the plan of revitalizing the deve-

lopment of football and ice and snow sports on the agenda, which affects the publication volume of studies of table tennis to some extent [12].

The annual publication quantity is a complicated process. According to the Price Law, the core is calculated in stages as follows: the publication volume of study literature in 2001–2003 is stable, so it is in a theoretical exploration stage; the volume is in a continuous increase in 2004–2008, so it is in a linear growth stage, and the discipline theory has been maturing; in 2009–2017, there is further deepening and improvement of the theoretical study of table tennis, so there is an irregular fluctuation in the curve. Seen from the tendency of the curve, the publication volumes at home and abroad would tend to be decreasing, and the gap would narrow gradually. In 2018–2020, there is a significant decline in the publication volume, and it is at its historical lowest point in 2020 [14].

Distribution of literature by author. The author is not only the core of the paper but also the smallest individual unit of scientific research. The study of authoritative scholars could rapidly master the status of one study field so that the study and learning objectives could be correct to reach the point [2, 3]. The author is the subject of scientific activity, and the quantity and quality of scientific research outcomes could reflect his knowledge contribution to this study field and his influence in this study field (Fig. 2). The authors with high output in the study field could show their depth and breadth in this field to some extent. The height of achievement of the researchers in their field is closely related to the number of papers published in important journals. The quantity of high-quality paper is directly proportional to scientific and technological achievements.

The number of publications and cooperation of authors would show the distribution of authors in literature. Firstly, there is a statistic on the literature publication volume of authors on the project of table tennis in 2001–2020. The author with the highest publication volume is Xiao Dandan, with 24 publications. Xiao is followed by Wu Fei, Zhang Yingqiu, and Zhou Xingdong (Fig. 3). The number of core authors is calculated according to Price Law:  $M = \sqrt{(0.749 \times N_{\max})}$  ( $M$  is the minimum number of publications that should be published by the core author, and  $N_{\max}$  refers to the number of publications published by the most productive author in the academic field).  $M \approx 2.900$ , is near 3, so it is confirmed that

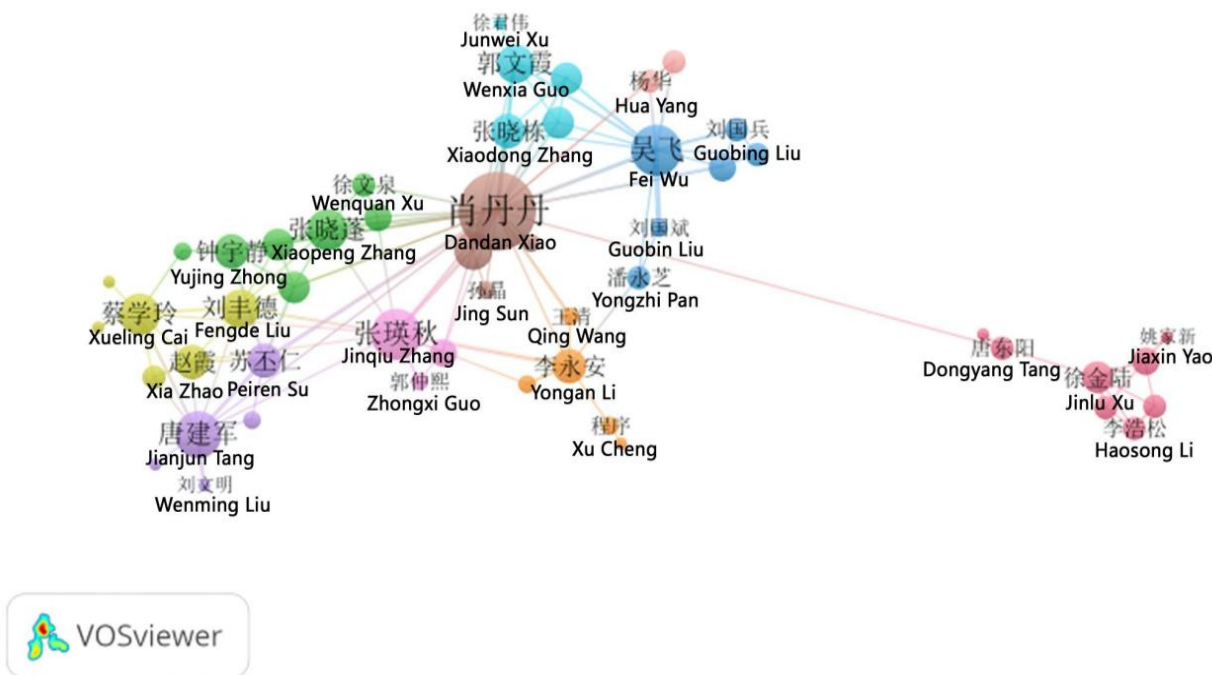


Fig. 2. Distribution of Authors in the field

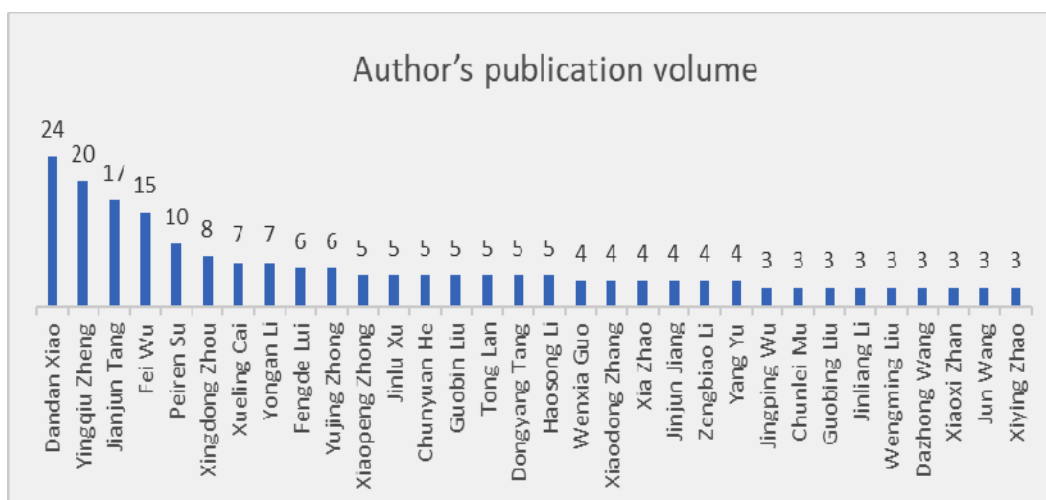


Fig. 3. Publication Volumes by Authors

the core authors in the field of table tennis should be those who have published 3 and above publications, and there are a total of 32 [8]. Fig. 3 presents 32 authors who have published 3 or more papers.

Fig. 2 includes 47 nodes and 120 lines, and each node stands for one author. The publication volume of the author is directly proportional to the size of the node, so bigger nodes mean a higher volume for the author. The lines between nodes indicate cooperation between authors. The closeness of cooperation is directly proportional to the thickness of the connection. Xiao Dandan, Zhang Yingqiu, Tang Jianjun, Wu Fei,

Su Peiren, and Cai Xueling are productive authors and authoritative experts with high output in the field of table tennis. Xiao Dandan in the China Institute of Sport Science has the biggest node, which means that Xiao is the scientific research leader in the field of table tennis [10].

According to the observation of the lines between nodes, in the field of table tennis techniques and tactics in China, the authors have close cooperation, so it is formed with an academic team with the core of Xiao Dandan, Su Peiren, Tang Jianjun, Wu Fei, et al., but there is less academic exchange among all teams [9]. Through the review of the literature, all-academic

teams are still engaged in all fields of the scientific study of table tennis [5].

It is suggested that the following studies should focus on data analysis; the main study direction of all teams is scriptwriting and data mining of table tennis technical and tactical analysis software.

Analysis of keywords in study papers on table tennis in China

A knowledge graph is drawn with the study object “keyword” to gain Fig. 4.

As seen from Fig. 4, each toroidal node stands for one keyword, and the node will be bigger when the frequency of the keyword is higher. The line between nodes means two nodes appear in the same publication [6]. In the picture, the nodes and fonts of different sizes can be directly seen. Table tennis is the most outstanding node and font in the picture, which means that table tennis frequently occurs in the paper. The node of table tennis includes the teaching of table tennis, techniques, athletes, etc. The competitive sports, as a node and font connected with table tennis, are larger. Then, it is followed by China, table tennis sport, Chinese table tennis team, athletes, techniques, and tactics [1].

The relevant keyword data is concluded according to the clustering graph of keywords in table tennis analysis and research in China. The top ten keywords with the highest frequency are selected with Excel to gain a statistical chart

of high-frequency and high-centrality keywords, this data is presented in Fig. 5.

As seen in Fig. 5, there are the top ten hotspot keywords. The first one is “table tennis” with a number of 318; the second one is “competitive sports” with a number of 68; and the third one is “techniques and tactics” with a number of 41. The fourth one is “athletes”, with a number of 32; “China”, with a number of 30, and the “Chinese table tennis team”, with a number of 30. Their centralities are higher. While the centralities of “training” with a number of 25, “Rong Guotuan” with a number of 24, “table tennis sport” with a number of 21, and “teenager” with a number of 18 are lower.

Distribution and analysis of study hotspots. There is a statistic on 677 publications in core journals, which are included in the CNKI, so as to have a better sorting and analysis of the hotspot issue of table tennis. It would provide a reference for the theoretical development direction of table tennis in the future.

The higher frequency and bigger nodes of hotspots shown in the VOSviewer indicate a high degree of activity in the field and a new tendency and field of study. As shown in Fig. 6, the hotspots in the field of table tennis are technical and tactical analysis, stalemate segment, return of service, technical and tactical features, Ma Long, Fan Zhengdong, table tennis sport, competitive sports, new rule, data mining, training, and other

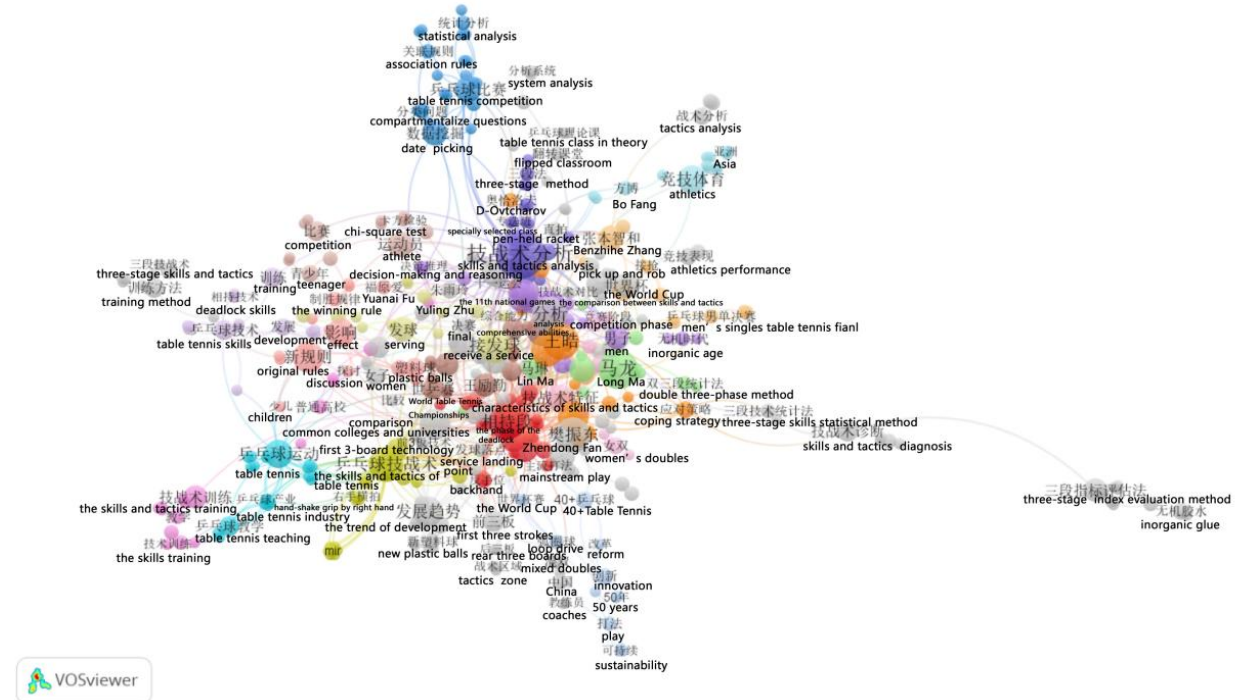


Fig. 4. Keyword Analysis



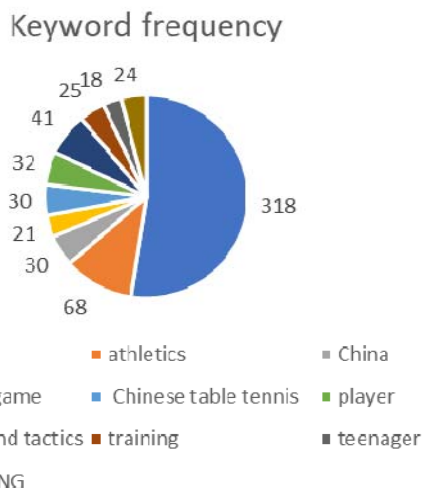


Fig. 5. Frequency of keywords

hotspot words. All of these words are detected according to the sharp increase in the frequency of use of the keyword in the literature in a certain year. Among these hotspot words, there are four related to techniques and tactics: technical and tactical analysis, return of service, technical and tactical features, and stalemate segment. There are analyses by period of time: “techniques” from 2001 to 2009, “tactics” from 2015 to 2021. Chinese scholars have studied the techniques and tactics for nearly 20 years, which shows that the lasting study hotspots in the field of table tennis are the techniques and tactics of competitive table tennis. It also means that the table tennis science and technology workers have spent vast amounts of time and energy in the backstage of the glory of the national ball to gain much more study achievements. The interdisciplinary study of

“data mining” would have a bigger development prospect in this field. The study of the direction is added to by an exploration of scholars in the disciplines of computer science and artificial intelligence. They have explored the visual system, real-time tracking, and algorithm of table tennis robots. The current table tennis techniques and tactics have been close to the human limit in terms of speed, rotation, and force. The interdisciplinary cooperation between the experts in table tennis work and others in other study fields would have more effective and practical study outcomes.

The most important hotspot keywords are “Ma Long”, “Fan Zhendong”, “competitive sports”, “new rule”, and so on. Combined with the viewpoints of multiple researchers, the hotspots of table tennis in this period focus on competitive competition. Firstly, Ma Long and Fan Zhendong will participate in the Tokyo Olympic Games, so there is a heated discussion on their use of techniques and tactics in the Olympic Games, World Table Tennis Championships, and Table Tennis World Cup during the period. The study methods are diversified, such as the wide application of methods used in sociology, economics, and demography in the analysis of table tennis’s techniques and tactics [13], building up a “technical efficiency formula” with the relationship of the gain and loss points and utilization rate for evaluating the use efficiency of competition techniques and tactics. Secondly, in the aspect of tactical behavior and theory, “mixed strategies” and “mixed strategy Nash equilibrium” in the field of game theory are also applied to the tactical discussion of service and

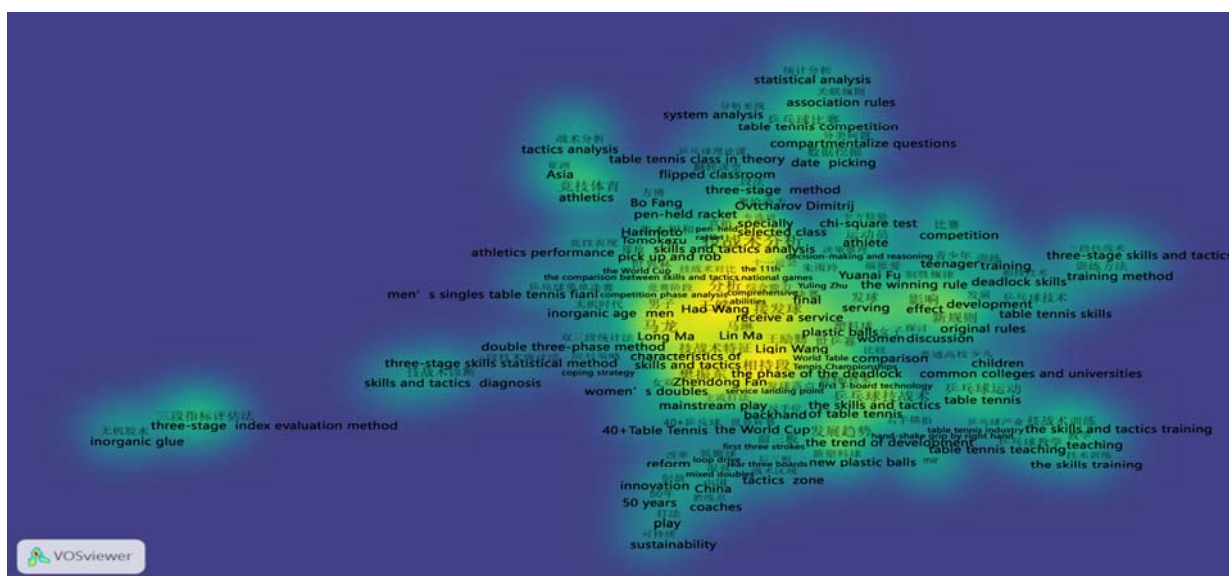


Fig. 6. Hotspots Distribution Picture

receiving. Some scholars describe the game theory of tactical behavior in table tennis from three perspectives: concepts, elements, and genus. The table tennis tactical behavior analysis model is verified with empirical study so that it is possible to predict the athletes' tactical behaviors in the competition [7]. As for the "new rule", with years of development, more and more scholars have made great contributions to the study of scientific research on table tennis in sports journals, and the content indicators of study have become more and more mature to form a stable development. International table tennis research has carried out an important reform in the history of this sport since this century. The diameter of the table tennis ball had been enlarged from 38 mm to 40 mm on October 1st, 2000, and the weight of the ball was increased as well, with 2.7g added to the original weight. One year later, there was also an adjustment in the competition rules, with the original 21 points per game being adjusted to 11 points per game. The service rules were changed from the original five-point service to a two-point service. Two years later, the service rule was limited, so there was a wider space to change the rule of the sport with the application of unobstructed service and limitless glue. For table tennis, the application of 11 points per game, unobstructed service, a big ball, and limitless glue would generate a very profound impact. The table tennis sport would keep changing along with the ceaseless development of the competitive sport.

### Conclusion

(1) Through the study of 16 sports core journals, it is concluded that the one with the highest publication volume is the *Journal of Beijing Sport University* with a volume of 96, accounting for 14.18%; the second one is *Sports Culture Guide* with a volume of 71, accounting for 10.49%; and the third one is the *Journal of Shenyang Sport University*.

(2) According to the publication volume of the literature related to table tennis, the volume in 2001–2003 was stable in a theoretical exploration stage, and there was a continuous increase in 2004–2008 in a linear growth stage, so the discipline theory is mature. In 2009–2017, there was further deepening and improvement in the theory of table tennis, and there was an irregular fluctuation in the curve. Seen from the tendency of the curve, the publication volumes at home and abroad would tend to be decreasing, and the gap would narrow gradually. In 2018–2020, there is

a significant decline in the publication volume, and it is at its historical lowest point in 2020.

(3) The main scholars in China are Xiao Dandan, Wu Fei, Zhang Yingqiu, Zhou Xingdong, and Tang Jianjun, and academic teams in the relevant fields have been built with the core of these authors with high output. However, there is less communication among these teams, so it is hoped that they could enhance communication with each other. The colleges and universities are the most important battlefield for the analysis and study of table tennis sport, and the core institutions are Beijing Sport University, Shanghai University of Sport, and so on. The study outcomes feature a significant regional difference. There are abundant outcomes in Beijing and Shanghai, but it is almost a blank in the central and western regions.

(4) The main points studied in the table tennis sport are based on table tennis, competitive sports, techniques and tactics, athletes, Chinese table tennis, etc.

### Suggestions

(1) China should pay more attention to the theory of table tennis in the future, especially at the normal and comprehensive universities in China. They should increase the publication quantity of sports core journals so that they can make more contributions to the theory development of table tennis.

(2) The cooperation and communication among all study institutions should be enhanced, especially among the professional sports colleges and scientific research teams. The construction of a scientific research team of college teachers in table tennis theoretical research should be enhanced. Governments and other departments should also maintain a balanced allocation of educational resources and teachers in Chinese colleges and universities to enhance the construction of scientific research teams in colleges and universities in remote areas of Western China.

(3) The teachers in the domestic colleges and universities should have continuous research on table tennis theory, and their publication volume should not be changed along with the occurrence and disappearance of hotspot issues or events because only continuous researchers could have a more systemic and deeper method to find out problems and determine the development tendency of the field. The master's and doctoral students of table tennis should broaden their horizons and extend the study field in future studies to seek new study hotspots and innovative study fields.



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