Research Article
Dynamic Analysis of International Swimming Research Using CITESPACE

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These days, the visual analysis of the literature (using the Web of Science as the data source) in the field of international swimming has been used to clarify the current status and patterns of research in this field. The data source of web of science provides a reference for the dynamic update of international swimming research. In this paper, we have used CiteSpace software and applied it to analyze the core literature related to international swimming from 1998 to 2020 in terms of overall literature measurement, core authors, source institutions, country distribution, discipline distribution, research hotspots, frontiers, and so on. We performed numerous experimental works for dynamic analysis of international swimming research using this tool. The findings indicate that international swimming research is in the second (growth) stage of the “Lepus curve,” and that there is a “head effect” in the distribution of journals (primarily in sports medicine). We obtained these large core cooperative networks, forming some high-production institutions as the core of large-scale cooperative networks and comprehensive university high-production institutions. In the future, we plan to focus on sports injury and rehabilitation, physiological characteristics, biomechanical analysis, and reaction in the future.

1. Introduction

Swimming is a personal and team competition activity that demands players to swim through the water with their complete bodies. The sport is played in either pools or Deep Ocean. Swimming is among the most famous Olympic sports, with distance categories ranging from butterfly to backstroke to breaststroke to freestyle and individual medley. Aside from these solo competitions, four divers can compete in a freestyle or butterfly relay. The authors of [1] designed a medley relay consisting of four swimmers who will each swim a distinct technique, in the following order: backstroke, breaststroke, butterfly, and freestyle. Swimming performance can be determined by optimizing velocity while reducing adverse influences. Muscle strength and endurance are two of the most important aspects of optimizing propulsion [2]. The elbow complex has previously been investigated in terms of muscle function [3], biomechanics [4], and accident incidence [5]. While repeated and continual knee flexion is necessary for swimming propulsion, swimmers’ knee muscle function has seldom been studied [6].

In the context of the knowledge and information explosion in the twenty-first century, the global swimming research literature has seen “explosive” growth, and the research perspective has been expanded. In addition, the research content has been refined, which has played a positive role in expanding the level and depth of research issues. The vast amount of literature provides solid theoretical support for the development of swimming in various countries but makes it more and more difficult for swimming coaches, teachers, and researchers to select valuable literature [7]. Therefore, it is difficult to get the literature they need from the vast amount of research results, so they
cannot accurately grasp the world swimming research trend. This has caused certain constraints to the development of swimming teaching, training, and research work. It is necessary to adopt a scientific method to systematically sort out the massive literature on international swimming and scientifically understand the research dynamics in this field [8]. Among them, scientific knowledge mapping, as an effective knowledge management tool in scientometrics, has been applied more and more widely in the fields of medicine, education, kinesiology, sports training, management, and library intelligence in recent years.

Based on the above, this study adopts CITESPACE visual analysis software to visualize and analyze the literature related to international swimming research, which can provide a concise. Images may effectively depict the dynamic growth pattern in the area of international swimming, allowing for a direct and effective comprehension of the research state of international swimming in recent years. Furthermore, it serves as a simple and useful reference for relevant study. The goal of this work is to create and evaluate a novel and specialized framework for the accurate definition of international swimming and its dynamic energy behavior. To do this, a module that calculates evaporation and other energy loss is presented and linked as a new component specified in Bicomb for a dynamic simulation of the issue. The work done verifies the system and proves the use of dynamic modeling techniques in solving complicated thermal conditions such as energy consumption in dynamic international swimming. The new dynamic simulation model also performed a risk assessment of the energy consumption for the facility’s primary control factors, proposing set points for more efficient operation of these facilities.

We gathered and studied the journal articles on international swimming from 1998 to 2020, with the goal of

1. Exploring the present research state in international swimming through knowledge modeling;
2. Identifying the major nations and organizations;
3. Finding the key authors and topic categories;
4. Categorizing the cocitation clusters;
5. Proposing the primary continuing development of international swimming investigation.

In this approach, it is feasible to enhance and deepen research on international swimming while also providing scientific recommendations for swimming reconstruction and long-term social and economic growth.

The rest of this paper is organized as follows. Section 2 is based on our research mythology and data source used in our proposed work, Section 3 explains our measurement for the visualization analysis of an issue, Section 4 is based on the analysis of research institutions and collaborations and Section 5 concludes our research work for dynamic analysis of international swimming.

2. Research Methodology and Data Sources

2.1. Research Methodology. Bibliometrics is a method that takes the literature system and bibliometric features as the research object and conducts a statistical analysis of literature data. It studies the structure of literature distribution, quantitative relationships, and change patterns. After that, it grasps the structural relationships, research contents, and research hotspots of disciplines by predicting the frontiers and trends of disciplinary development on this basis. However, in the current context of large and diverse research data, rapid growth, and low information content, traditional bibliometric methods are difficult to cope with, so CITE-SPACE visual analysis software is used for supplementary data analysis. Based on the idea of “co-occurrence clustering”, the software extracts information units such as research publications, journal distribution, highly cited literature, research authors and collaborations, research institutions and collaborations, country distribution and collaborations, research themes and frontiers, and reconstructs them according to the connection type and information intensity between the units. After that, it forms keyword clusters, and the structure of keyword clustering, timeline, and keyword emergence is used to track the hotspots and development trends of research fields and to understand the research frontiers and key evolutionary paths of research fields.

2.1.1. Analysis of CiteSpace Knowledge Plotting. The knowledge domain may be used to map a set of graphs that depict the link between the knowledge production process and the architecture. They employ visual graphics to characterize knowledge assets and carriers, as well as to search, analyze, create, sketch, and show knowledge and its linkages [9, 10]. Dr. Chen Chaomei USA’s CiteSpace citation visualization and analysis program have been widely and effectively used in various research [11, 12]. It can show the relative location of information within its specific knowledge domain. Furthermore, it may show the border of disciplinary study and forecast a field’s growth pattern. As a result, it is widely used in a variety of domains, including information theory, library science, knowledge and information distribution, finance, and psychology [13].

CiteSpace, which was initially developed by French bibliometrics called Callon, uses co-word analysis and cocitation functions to identify research hotspots and frontier concerns. It is typically designed as follows. Initially, the number of repetitions of a set of terms in pairings is tallied in the same document. The words are then subjected to a clustering algorithm to indicate their near and distant associations [14]. It analyses a specified group of texts that are indicative of a discipline using multidimensional data analysis techniques. These include computer-aided clustering analysis and multidimensional scaling. It has the potential to reduce the complicated cocitation network of interactions among several objects of investigation to connections between select classes with relatively modest numbers and present them clearly [15]. Figure 1 depicts the flow diagram of analysis of CiteSpace bibliometric.

2.2. Data Sources. Data sources are designed to assist users and programs in connecting to and sending information to where it is needed. They collect and hide key technical data.
3.1. Quantitative Trend Analysis. This section contains our quantitative trend analysis, which is used to gain a better understanding of the social environment. In this work, we utilize quantitative tools to investigate events and situations that have an impact on individuals. Our quantitative approach generates objective data that may be conveyed in the form of statistics and data.

The annual and cumulative number of publications in this field was used as the base data for regression analysis. Figure 2 explains the cumulative amount of literature on swimming research abroad.

It can be seen from the above figure that the research on international swimming can be roughly divided into two stages: the first stage is from 1998 to 2014, which is the initial stage of the research on international swimming. It starts from the first core article published in 1998, the annual publication volume shows a fluctuating trend of growth, but the cumulative publication volume is small on the whole, in line with the pattern of “slow development in the first stage”. The second stage is from 2015 to 2020, and the annual publication volume is always maintained at a high level. The approximate index of the corresponding cumulative publication volume also increases significantly, entering the stage of “accelerated development in the middle and early stages”. This shows that the research on international swimming is in “The number of articles published and the cumulative number of articles published on swimming will continue to grow rapidly”.

3.2. Analysis of the Distribution of Research Journals. Distribution research is the collecting and examination of data about scientific publications and their dissemination across different retail channels to assist management in making important choices. The details of Journal distribution of swimming research abroad can be explained in Figure 3.

The statistics in the above figure shows show that the literature on international swimming sports research is mainly concentrated in “Medicine and science in sports and exercise”, “Journal of Strength and Conditioning research” and “Journal of sports sciences”. In three journals, the cumulative number of articles published reached 51.62%, among which “Medicine and science in sports and exercise” published the most research literature on swimming sports, with 267 articles, much higher than the other two journals. In addition, “International Journal of sports medicine”, “Journal of applied biomechanics”, “Research quarterly for exercise and sport”, “International Journal of sports physiology and performance”, “European Journal of applied physiology”, “Biology of sport” and “British journal of sports medicine”, the cumulative number of articles on swimming sports research in 7 journals is also relatively high and balanced. The remaining 11 journals have a relatively low cumulative number of articles on swimming research. It can be seen that international swimming focuses on the use of multidisciplinary theories and methods to study the characteristics and laws of swimming.

3.3. Analysis of Highly Cited Literature. This section explains the comparison of cited references of foreign core journals of swimming sports with high citation frequency. Here, we have chosen the 10 citations with the highest citation frequencies [17]. We have divided these citations into five categories, i.e., their citation frequency, title, name of the author, concerned Journal, and publication year. The top ten

![Figure 1: Flow diagram of the CiteSpace bibliometric analysis.](image-url)
Table 1: Literature sources at home and abroad.

<table>
<thead>
<tr>
<th>Database</th>
<th>Periodicals</th>
</tr>
</thead>
</table>

![Figure 2: The cumulative amount of literature on swimming research.](image)

Cumulative literature

- Observed value (O)
- exponential distribution (E)

rated swimming literature was summarized based on the frequency of citations in the Web of Science core collection database. It can be shown that the highly referenced worldwide swimming literature is largely experimental, with study themes focusing on three areas: swimming technique, sports injury, and medical experimental investigation of swimming training in rats. Table 2 explains a summary of the top 10 ranked literature in the field of swimming.

From the above figure, it is clear that the literature on “Energetics and biomechanics as determining factors of swimming performance: Updating the state of the art” and “The ecological validity and application of the SESSION-RPE method for quantifying training loads in swimming” have the highest frequencies (such as 128) as compared to the rest one.

3.4. Study Authorship and Collaboration Analysis

3.4.1. Analysis of Study High-Yield Authors. Bicomb software was used for the statistical analysis, and the frequency of the top ten writers was recorded. Table 3 describes the frequency with which writers of international core journals of swimming sports research publish. Vilas-Boas, JP, is clearly placed top in the major research path of swimming methods. Fernandes, who finished second, concentrated on the aerobic capacity of swimming sports skills. Marinho, who placed third, mostly focused on various elements of elite swimming athletes. Barbosa came in fourth place and also specialized in sports injuries. Fernandes, Ricardo J, Silva, AJ, and Pyne, who is rated fifth, sixth, and seventh, are all studying players from the standpoint of sports injuries. Burkett, rated eighth, studies impaired swimmers as his primary research focus. The ninth and tenth ranked Stager, JM, and Joao-Paulo, whose primary research focus is sports physiology, Paulo’s primary scientific interests are in exercise physiology.

From the authors, we can see that most of the researchers are from universities, which shows that universities are the main place for swimming research. There is an external penetration of disciplines in international swimming research.

3.4.2. Analysis of Study Authors and Collaborations. Figure 4 shows the author cooperation of swimming research abroad. Statistics show that there are 133 collaborative nodes and 118 collaborative links in the author collaboration map of international swimming sports research, with a collaboration density of 0.0134.

Although the authors as a whole are scattered, there are more nodes clustered, more links, and more exchanges and collaborations conducted in small groups. This indicates that there are more scholars in international swimming, more independent studies, and collaborative studies. Some of them have formed relatively stable collaborative relationships in this field of research. Moreover, the intensive linkage between some authors indicates that the research in this field has formed a large-scale communication and cooperation behavior. In addition, the related communication and cooperation are frequent and intensive, and the number of scholars involved in collaborative research will be increasing. Further analysis shows that Vilas-Boas, JP, Fernandes, RJ, Marinho DA, Barbosa, TM, Ricardo J, Silva, AJ, Pyne, DB, Burkett, B, Stager, JM, Joao-Paulo, and 10 others are highly productive international swimming sport research authors. Some of their results have high citation frequency in the field and become authoritative literature in certain research areas of swimming sports. They have a closer network of collaborative relationships with other scholars. In terms of a collaborative network, a research network with two scholars, Marinho DA and Silva AJ, as the core, formed the largest collaborative network between these two scholars and others.
Table 2: Overview of top 10 studies in swimming.

<table>
<thead>
<tr>
<th>S#</th>
<th>Frequency</th>
<th>Title</th>
<th>Author</th>
<th>Journal</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>128</td>
<td>Energetics and biomechanics as determining factors of swimming performance: Updating the state of the art.</td>
<td>T.M. BARBOSA et. Al [18]</td>
<td>Journal of science and medicine in sport</td>
<td>2010</td>
</tr>
<tr>
<td>3</td>
<td>113</td>
<td>Sleep or swim? Early-morning training severely restricts the amount of sleep obtained by elite swimmers</td>
<td>C SARGENT et. Al [20]</td>
<td>European journal of sport science</td>
<td>2014</td>
</tr>
<tr>
<td>5</td>
<td>97</td>
<td>Effect of swimming velocity on arm coordination in the front crawl: a Dynamic analysis</td>
<td>L SEIFERT et. Al [22]</td>
<td>Journal of sports sciences</td>
<td>2004</td>
</tr>
</tbody>
</table>

Table 3: Frequency table of publication by authors of foreign core journals of swimming sports research.

<table>
<thead>
<tr>
<th>S#</th>
<th>Number</th>
<th>Author</th>
<th>Most cited</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>33</td>
<td>Vilas-Boas, JP</td>
<td>81</td>
<td>University of Porto</td>
</tr>
<tr>
<td>2</td>
<td>27</td>
<td>Fernandes, RJ</td>
<td>80</td>
<td>University of Porto</td>
</tr>
<tr>
<td>3</td>
<td>26</td>
<td>Marinho, DA</td>
<td>37</td>
<td>Bella Inner University</td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>Barbosa, TM</td>
<td>54</td>
<td>Nanyang Technological University</td>
</tr>
<tr>
<td>5</td>
<td>19</td>
<td>Fernandes, Ricardo J.</td>
<td>28</td>
<td>University of Porto</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>Silva, AJ</td>
<td>21</td>
<td>University of Patras</td>
</tr>
<tr>
<td>7</td>
<td>19</td>
<td>Pyne, DB</td>
<td>17</td>
<td>University of Patras</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>Burkett, B</td>
<td>10</td>
<td>University of the Sunshine coast</td>
</tr>
<tr>
<td>9</td>
<td>16</td>
<td>Stager, JM</td>
<td>7</td>
<td>Indiana University Bloomington</td>
</tr>
<tr>
<td>10</td>
<td>16</td>
<td>Joao-Paulo</td>
<td>19</td>
<td>University of Tras-os-Montes and Alto Douro</td>
</tr>
</tbody>
</table>
in the research of swimming sports and became the international leaders in the field. Figure 5 shows the author cooperation time zone map of domestic swimming research abroad.

From the perspective of research cooperation, before 2008, most of the research was mainly independent research, no large-scale cooperation network was formed, and small-scale local cooperation was also relatively small. Since 2008, the cooperation research in international swimming research has increased significantly, and some large-scale cooperation networks have been formed centering on Portuguese university physical education experts, and more detailed research has been carried out around swimming sports training. There are more frequent exchanges, more cooperative behaviors, and more scholars involved in cooperation. Since 2012, scholars from other countries have paid significantly more attention to swimming. Due to this more and more scholars have been involved in swimming research, and several relatively small-scale cooperative networks have been formed based on the original large-scale cooperative networks. However, compared with 2008–2012 this phase has not formed a larger scale. The network of cooperation was not formed in this period compared with 2008–2012.

4. Analysis of Research Institutions and Collaborations

4.1. Analysis of High-Yield Institutions. This section describes the Bicomb program that was used to extract high-frequency keywords and build a content matrix. The matrix was sent into the program, which is used for better analysis
to discover hotspots that could be shown as mountains and matrices [28]. The frequency of publishing of institutions that publish material relevant to swimming sports research in core sports journals was counted using Bicomb software, and 157 institutions published more than twice. The institutions with the most publications were sorted and extracted. Following that, the top ten most productive institutions were sorted and extracted. The frequency of publishing of swimming sports research institutions in the foreign core is compared in Table 4.

The top 10 research institutes in terms of institutional publications are all university institutions. This suggests that university educational institutions, not simply sports institutions, but also more comprehensive institutions, have the dominant position in worldwide swimming sports movement research.

### 4.2. Research Institutions and Collaborative Analysis

Figure 6 shows the cooperation of swimming research institutions abroad. The cooccurrence network map of significant institutions in worldwide swimming research shows that this institution has 78 nodes, 45 lines, and a density of 0.015. Comprehensive universities and sports colleges are the most prolific institutions in this field, and comprehensive universities are the most prolific institutions in this field, as are the national conditions of swimming in Australia and the training mechanism of swimming reserve talents, among other things. Except for the top ten most productive institutions, which are all comprehensive universities, the Australian Institute of Sport (AIS). It is responsible for talent development, plays an essential role in swimming research, and has become the backbone of worldwide swimming research. Comprehensive universities’ sports faculties have played an essential role in swimming research. It provides intellectual and theoretical support for the growth of swimming through joint research. Except for certain high-producing institutions with more extensive and thicker collaboration linkages, research institution cooperation is fragmented. The rest of the high-producing institutions have fewer and thinner cooperation links, while a large part of institutions are not connected, which indicates that the large-scale cooperation of international swimming research institutions is still low.

Only individual high-producing institutions have formed good communication and cooperation relationships with other institutions, and the intensity of cooperation is more stable. Most of the institutions are still independent and lack close communication and cooperation with other institutions. The majority of the relationships are cold, indicating that the strength and intensity of cooperation are not as strong as they were previously.

Figure 7 shows the time zone chart of domestic swimming research institutions cooperation abroad. This figure shows that the Australian Institute of Sport began researching swimming early, laying the groundwork for future study in this discipline. These institutions are engaging in increasing cross-regional exchanges and collaboration.

<table>
<thead>
<tr>
<th>#</th>
<th>Institution</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Univ Porto</td>
<td>33</td>
</tr>
<tr>
<td>2</td>
<td>Australian Inst Sport</td>
<td>31</td>
</tr>
<tr>
<td>3</td>
<td>Indiana Univ</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>Univ Beira Interior</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>Univ Sunshine coast</td>
<td>8</td>
</tr>
<tr>
<td>6</td>
<td>Univ Sao Paulo</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Univ Tras Os Montes and Alto Douro</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Univ Rouen</td>
<td>6</td>
</tr>
<tr>
<td>9</td>
<td>Univ Pittsburgh</td>
<td>6</td>
</tr>
<tr>
<td>10</td>
<td>Univ Western Australia</td>
<td>5</td>
</tr>
</tbody>
</table>

Furthermore, some institutions, particularly universities, have established more solid cooperative connections, which are more intensive and continue longer. It demonstrates the institution’s focus and priority on swimming.

After entering the new century, the increased attention to swimming in the world has improved the attention to swimming in the academic field. Due to this, more and more research institutions have begun to pay attention to the research field of swimming. In this regard, the University of Sao Paulo in Brazil, the University of Canberra in Australia, and Indiana University in the United States have also carried out research in this field and formed some small-scale cooperation networks. From Beijing Olympic Games to London Olympic Games, the cooperation of comprehensive universities in swimming increased, forming a large-scale cooperation network with the University of Porto in Portugal as the core. The universities in the United States, Australia, Greece, and other countries successively participated in cooperative research in this field and carried out rich research from different perspectives. The density of institutional cooperation in this stage was greater and the cooperation after 2012, institutions did not form a large-scale cooperative network in swimming sports research, but mostly some small-scale local cooperation, and the intensity of cooperation weakened.

#### 4.2.1. Country Distribution and Cooperation Analysis

Through CITESPACE, a network of national collaborations in swimming research can be constructed to analyze the macrolevel of swimming research and thus grasp the distribution of research power in the world in the field of swimming research [29]. Figure 8 explains the copresentation of major research countries in swimming sports research.

This network graph consists of 71 nodes and 110 connections, with a network density of 0.0443. The quantity and strength of linkages between network nodes in the knowledge graph may be used to investigate the level of cooperation between nations (regions). The color of the linkages symbolizes country collaboration in the temporal dimension, while the size of the nodes shows how frequently nations provide articles.

The regions publication frequency of countries is shown in Table 5. The United States has the greatest international
Figure 6: Cooperation of swimming research institutions abroad.

Figure 7: Timezone chart of domestic swimming research institutions cooperation abroad.

Figure 8: Copresentation of major research countries in swimming sports research.
research literature on swimming, followed by Australia, Portugal, the United Kingdom, China, and other nations, while France and Brazil have developed a certain scale of cooperation network in swimming research. In contrast, the improvement of swimming levels in Asia in recent years has led to a significant increase in the research on swimming in different Asian countries, especially in China, Japan, and Korea, where there are more researchers in swimming. The authors of European swimming have the most distribution in the UK, concentrated in the England region, and researchers in North America are mainly concentrated in the USA and Canada. In Oceania, Australia and New Zealand have more external cooperation in this field. Swimming authors in Australia are mostly concentrated around the southeast coast, particularly in Canberra.

4.3.1. Keyword Analysis of International Swimming Sports Research. The comparison among the keywords cooccurrence map of domestic swimming research abroad is shown in Figure 9. In the keyword cooccurrence map of international swimmer research, there are 107 nodes and 204 links, with a density of 0.036, indicating a high degree of association between keywords. Among them, the keywords with high-frequency are "swimming", "exercise", "performance", "performance", "speed", "speed" and "speed". Moreover, the "velocity" and "swimmer", and there are more and thicker lines between these keywords, indicating that there is a strong correlation between these keywords.

The comparison of the list of high-frequency keywords in foreign core journals of swimming sports research can be shown in Table 6. Among the different keywords of international swimming research, "swimming" has the highest frequency, reflecting the core content of the research. The keywords “training” ranks second, indicating that swimming research adheres to the basic concept of scientific research serving training, and focuses on solving some difficult and critical problems in swimming training. The frequency of "training" ranks second, which indicates that swimming research adheres to the basic concept of scientific research as a service to training, and focuses on solving some difficult and key problems in swimming training. The frequency of "performance" ranks third, which emphasizes how to improve athletes' performance through improving training to consolidate their position in swimming. The frequency of "physical fitness" ranks the fourth, which focuses on improving athletes' performance through introducing modern training concepts and techniques.

The frequency of "fitness" is fourth, with the emphasis on the introduction of innovative training concepts and ways to investigate athletes' physical skills and increase their fitness level. The frequency of "swimmers/swimmers" is sixth, concentrating on some swimmers' technical and tactical performance and assessing how to support their better growth.

4.3.2. Thematic Evolution of International Swimming Sport Research. Figure 10 depicts the keyword and time zone comparisons for international swimming research. This figure shows that, in chronological order, the leading keywords of worldwide swimming research from 1998 to 2020 were: swimming, training, physical fitness, biomechanics, performance, reaction, strength, fatigue, swimmers, distance, coordination, freestyle, excellence, excellent swimmers, stroke arm coordination, human skeletal muscle, movement, physiological function, training performance, sport, and injury. Among them, swimming and training were the first keywords that received attention. Following that, studies were carried out using the keywords physical fitness, biomechanics, performance, reaction, strength, fatigue, and swimmers.

The research at this stage was mainly aimed at improving the performance of athletes, with emphasis on research from...
physical fitness (strength training was the focus) and from a biomechanical perspective, so that they could recover from fatigue on time after heavy training. Simultaneously, scientific training techniques and tools are used to investigate their physical potential, which increases their physical level and results in exceptional performance. Since 2004, the study material on swimming sports has grown significantly, and the research has been conducted using keywords such as different distance events. (G_the previous study is based on different strokes, stroke arm coordination, and great swimmers, and the research is refined and segmented. After 2012, scholars increased the research on physiological function, training performance, sports, and injury of swimmers. They paid more attention to the tracking of athletes’ physiological function indexes in sports training by regulating training through physiological and biochemical indexes. They improve athletes’ training competition, at the same time preventing and reducing all kinds of sports injuries caused in training and competition.

4.3.3. Changes in the Content of International Swimming Sports Research. The keywords of international swimming research were aggregated into 6 clusters, namely “motor control”, “blood lactate”, “peripheral quantitative computed tomography,” “swimming,” “video analysis,” “respiratory”, and “taper”, all focused on clear themes. Figure 11 explains the keyword clustering graph of domestic swimming research abroad. Among these clusters, the largest cluster #0 is “motor control”, whose research direction is more focused. This cluster is focusing on the physical rehabilitation of swimmers after injury and the control of sports training movements. Cluster #1 is “blood lactate” because the blood lactate index is a sensitive index for assessing endurance quality. Since blood lactate is a sensitive indicator of endurance quality, it can evaluate the intensity of swimming training and the adaptability of athletes’ training. Many scholars focus on the tracking of blood lactate indicators during the training of swimmers, adjusting the training arrangement, especially the training load arrangement, so that athletes can better adapt to the training intensity and reduce the occurrence of sports injuries. Cluster #2 is “quantitative CT of peripheral bone”. “This is a new type of test to study the bone microstructure and assess bone strength, with short measurement time and simple operation. Here the error is usually less than 1%, and high reproducibility, through which we can understand the specific effects of different sports injuries on bone microstructure and bone strength of swimmers. Therefore, it provides a direct basis for targeted training.

On the other hand cluster, #3 is “swimming”, which is strongly correlated with other clusters, and the research mainly focuses on swimming training, physical training, strength training, performance, etc. Similarly, cluster #4 is “video analysis”, which is a new research area in recent years.
This is a new research field in recent years, with the help of video analysis, the athletes’ movements can be diagnosed and corresponding improvement means and suggestions can be made so that the athletes’ movements can be more refined and more economical and efficient. Cluster #5 is “breathing”, which mainly studies the control of athletes’ breathing, the coordination between breathing and movements, and the improvement of breathing skills (such as breathing muscle training). Finally, cluster #6 is “reduction”, which belongs to the category of training load, which refers to the gradual reduction of the exercise volume after the completion of the last large exercise week, to adjust the body to the best competition condition, and mainly studies the control of the load volume in the precompetition training to ensure that the athletes participate in the competition in the best condition. As a result, the keyword clusters are integrated, and cluster #0 and cluster #2 are combined as sports injury and rehabilitation. Cluster #1 and cluster #6 are combined as swimming training load, and cluster #3 and cluster #5 are combined as breathing and cooperation, which finally form three keyword clusters with more distinct and concentrated levels.

The keywords and timeline of domestic swimming research abroad can be illustrated in Figure 12.

This figure reveals that when international swimming research was just starting, there were fewer keywords, mainly distributed in cluster #1 and cluster #4, with physical training, imaging, and biomechanics as the focus of research. At the beginning of the new century, except for cluster #1, the rest of the clusters’ research started one after another. Especially the research on clusters 1 to 4 was richer. Since the Athens Olympic Games in 2004 and up to now, due to the increase of injuries caused by the increase in training difficulty, the research of motor control in cluster #0 has gradually emerged. Motor control is the ability to regulate or manage the mechanisms necessary for movement, and it has widely swum in rehabilitation medicine clinical rehabilitation, sports injury rehabilitation, preventive medicine rehabilitation, etc. With the increase of powerful international swimming sports training, the ensuing sports injuries more and more. For this purpose, many scholars have researched cybernetics techniques, while the research of cluster #4, cluster #3, and cluster #5 has increased significantly in that stage and always maintained a high research fervor. Cluster #2 and cluster #6 are significantly more than the above four clusters.

4.3.4. Frontier Analysis of International Swimming Sports Research. Figure 13 explains the citation emergent map of swimming research abroad. According to the analysis results of Cite Space software, a total of 25 burst words with high burst intensity (or high burst rate) were extracted from 1107 related documents. Excellent swimmer, response, distance, and freestyle are the four terms with the greatest burst intensity, with burst intensities of 4.6706, 4.4223, 3.902, and 3.7128, respectively. It is said to be linked to FINA’s reorganization during this time. Because high-tech swimsuits helped competitors establish many new world records at the Beijing Olympic Games, FINA has been working on reform since the Games to limit the effect of high-tech swimsuits on competition and make it more equitable. Since 2009, FINA introduced a series of new rules, and since 2010, the use of high-tech swimsuits has been banned. The changes in FINA reform measures on athletes’ performance became the focus of academic circles, and the research around swimmers became a hot spot. The frequency of the keyword “reaction” changed a lot from 2003 to 2006, and the scholars’ attention to exercise physiology and exercise biochemistry increased significantly in this period. The keyword “distance” changed more frequently from 2006 to 2012. In fact, with the Olympic
cycle and the London Olympic cycle, the pattern of the world swimming world has changed significantly. The advantage of European and American countries in swimming has narrowed, and the middle and long-distance events have been overtaken by emerging countries, which has attracted the attention of scholars. Furthermore, the frequency of the phrase "freestyle" has changed dramatically from 2014 to 2015, and the causes for this have been investigated. In addition, the frequency of the keyword "freestyle" changed a lot from 2014 to 2015, which may be related to the introduction of men’s and women’s freestyle relay events by FINA, and these new reform measures have also become the content of academic research. From the evolution of research themes, the future research frontiers in the field of international swimming will still focus on sports injury and rehabilitation, physiological characteristics, biomechanical analysis, reactions, etc.

5. Conclusion

The purpose of this study was to examine the current state and to highlight the benefits and limitations of dynamic analysis of international swimming through CiteSpace. Based on the findings of CiteSpace, the new study proposes active collaboration among researchers, nations, and organizations. The following are the main conclusions: First, international swimming research is in the second phase of literature growth and will continue to grow in the future due to the influence of major events, the introduction of FINA reform measures, and the interpenetration of multiple disciplines. Second, there is an obvious “head effect” in the distribution of international swimming sports research journals, including sports medicine and kinesiology, and the journals with the highest cumulative publication volume are those of sports medicine. Third, international swimming research has emerged with some influential leaders and some large-scale core cooperation networks, and future research cooperation in this field is showing a good development trend. Fourth, international swimming research has established various large-scale collaboration networks, the center of which is high-producing universities. Comprehensive universities are the most productive institutions in this field of research, with higher collaboration intensity, longer cooperation length, and greater cross-regional cooperation. Fifth, international swimming research hotspots focus on breathing and coordination, training load, sports injury and rehabilitation, and it is expected that future research will still focus on sports injury and rehabilitation, physiological characteristics, biomechanical analysis, and reaction. In the future, we planned to focus on sports injury and rehabilitation, physiological characteristics, biomechanical analysis, and reaction in the future.

Data Availability

All the data used in the paper and research study can be obtained from the principal author through an e-mail request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References


