

# Research hotspot and trend analysis of synchronized swimming in the 21st century

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**Abstract:** The bibliometric method is used to summarize, classify, analyze and summarize the relevant literature and scientific research papers of WOS database in 2000-2022, pointing out the hot spots and trends of current synchronized swimming theory research, in order to provide useful reference for synchronized swimming coaches and researchers.

**Keywords:** synchronized swimming; bibliometry

## 1. Introduction

The Olympic Games women's water event — synchronized swimming, combines human body, water, music and dance to give people the enjoyment of beauty. In recent years, with the technical level of all aspects, the international synchronized swimming has made rapid development and considerable progress. With the continuous development of synchronized swimming, our theoretical research needs keep up with the development and practical needs of synchronized swimming events, and gradually a relatively complete scientific research system. The author consulted the literature of synchronized swimming in WOS database since the 21st century and summarized, and looked forward the development trend of theoretical research of this project from different perspectives, in order to provide certain basis for the development of theoretical research of synchronized swimming project and the further improvement of competitive level.

## 2. Data sources and study methods

### 2.1 Data source

With Web of Science core database as the search source, select "advanced search" type and "Synchronized Swimming" as the theme word. The search time range is from January 1, 2000 to December 31, 2022, the literature type is paper and the language is English. A total of 438 initial were searched, and 438 retrieved articles were manually screened, excluding conference abstracts, journal soliciting manuscripts, news reports, etc. And 428 articles were finally obtained. The basic data conditions are shown in Table 1 below:

Table 1: Table of the literature search status

List of items	Table of literature
Database source	Web of Science Core database
retrieval mode	subject search
Retrieval type	"Synchronized Swimming"
Retrieval years	1.12000-2022.12.30
Type of literature	thesis
Literature language	English
The number of literature	428

### 2.2 Study Methods

The Citespace software in bibliometrics, which provides concise data-based results and intuitive graphical presentation of selected large amounts of literature data, has been favored by scholars of different professions for a relatively long time in the past. The use of scientific knowledge mapping for academic inquiry in the field of sports has a good foundation and certain achievements, but it also

suffers from the deficiencies of poor database compatibility and operational stability. Therefore, in this paper, with the help of COOC/VOS viewer bibliometric software, which is not only better in database compatibility but also has a more beautiful and clear pulse of result mapping nodes, the 428 valid literature data after nano-ranking are used to The keyword frequency, co-occurrence matrix network, cluster mapping, and evolution time zone mapping are used to clarify the hotspots of international synchronized swimming research and its characteristics, trend evolution path and its connotation.

### 3. Analysis of the research status quo

The 428 relevant documents collected were imported into COOC software after drawing the publication chart of international synchronized swimming research from 2000 to 2022; as shown in Figure 1, the number of publications never exceeded 10 from 2000 to 2003, and the annual number of publications did not exceed 20 from 2004 to 2009. After 2008, the number of articles has gradually increased. Since 2010, the annual number of articles has exceeded 20, and in 2013, it reached the highest in nearly 22 years, with 23 articles. This may be related to the hosting of the 2008 Beijing Olympics and the 2012 London Olympics. After 2016, there was another small climax, which may be related to the 2016 Rio Olympics and the 2017 FINA World Championships. The total number of documents has increased year by year, the growth rate is relatively flat, and the growth rate is stable. It can be seen that there will be more international scholars in the field of synchronized swimming, and there is still much room for progress in this field.

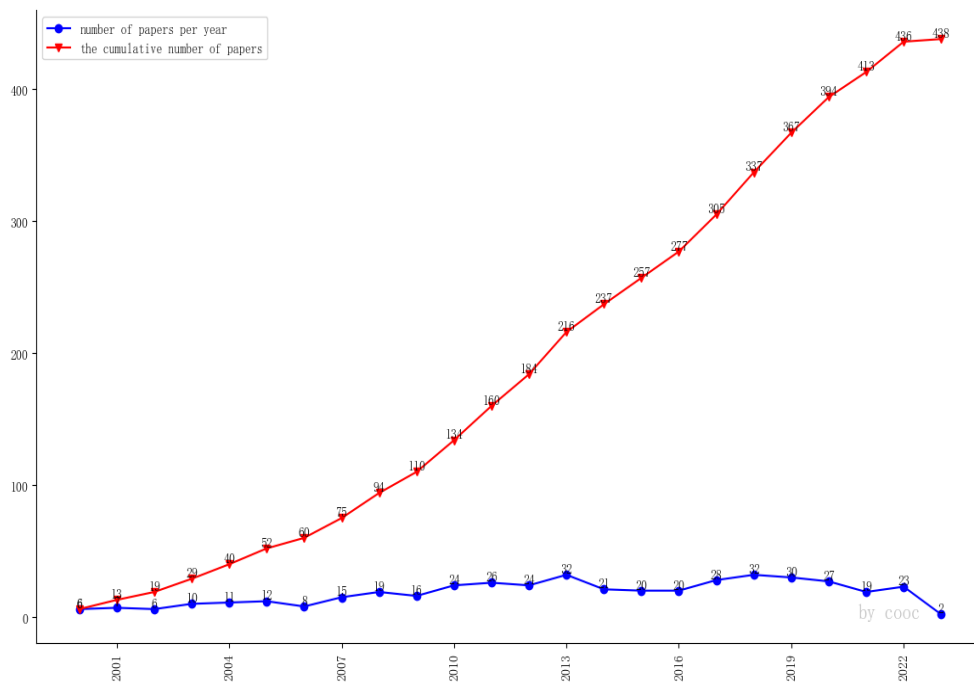


Figure 1: Document volume of international synchronized swimming research from 2000 to 2022

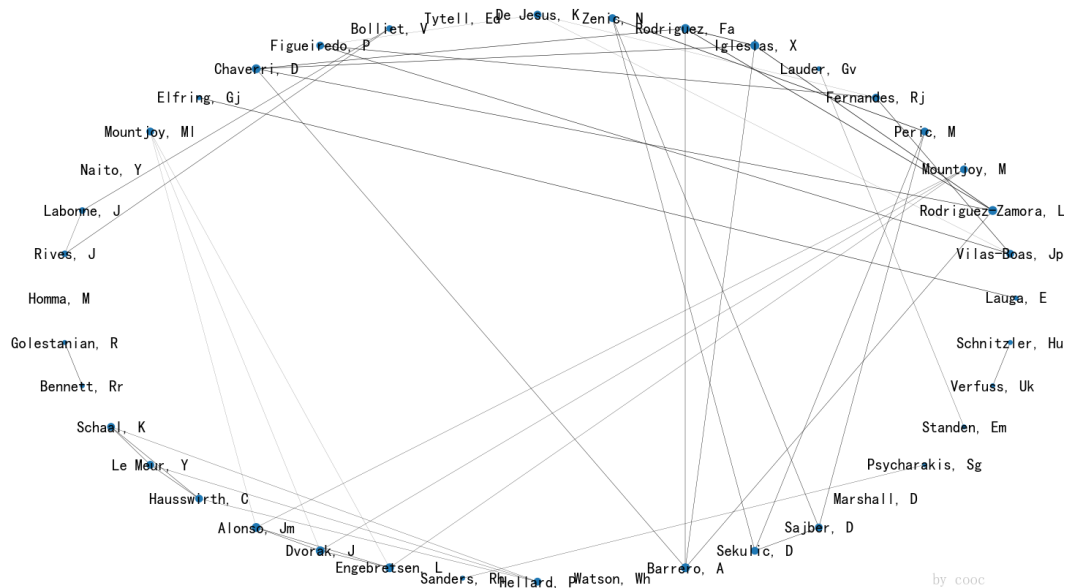
### 4. The authors' collaborative analysis

The COOC software was used to carry out frequency analysis and co-discovery analysis of the authors who published in the collected data in order to analyse the total number of authors who published and the collaboration of authors. The analysis revealed that there were 11 authors with 6 or more publications between 2000 and 2022, of which the most published scholar was Lauga, E with a total of 7 publications, the scholars Rodriguez-Zamora, L, Mountjoy, M, Vilas-Boas, Jp, Peric, M, Rodriguez -The total number of articles by Zamora, L is 6 and by scholars Zenic, N, Fernandes, Rj, Lauder, Gv, Iglesias, X, Rodriguez, Fa is 5. The total number of direct articles by authors is not high and not very different, with an average of 5.7 articles; this indicates that the research in this field is still shallow and that there is still room to strengthen the research on synchronised swimming by all scholars (See Table 2).

*Table 2: This research the author issuing scale*

Author	Post volume
Lauga, E	7
Rodriguez-Zamora, L	6
Mountjoy, M	6
Vilas-Boas, Jp	6
Peric, M	6
Rodriguez-Zamora, L	6
Zenic, N	5
Fernandes, Rj	5
Lauder, Gv	5
Iglesias, X	5
Rodriguez, Fa	5

The authors' cooperation is shown in figure 2. As can be seen from Figure 2, the overall cooperation rate among authors is low, and three author cooperation networks are mainly formed: Schaal, K, Le Meur, Y, Hausswirth, C, Hellard, P into a cooperative network, with Rodriguez-Zamora, L, Iglesias, X, Rodriguez, Fa, Chaverri, D, Barrero, A cooperative network of A and Peric, M, Zenic, N, Sekulic, D, Sajber, D to constitute a cooperative network. In general, the three cooperation networks have a large number of partners and the number of publications, and the cooperation is relatively close, but the cooperation objects are mostly teachers and apprentices or the same door, and the cross-academic institutions or interdisciplinary cooperation is less. There are also other smaller cooperative networks: with Bolliet, V, Labonne, J, Rives, J, and the cooperative network composed of Golestanian, R, Bennett, and Rr. In general, international scholars have not formed a broad and close cooperation network in the field of synchronized swimming, and the cooperation between researchers needs to be strengthened.



*Figure 2: International Synchronized Swimming Researchers Collaboration Network 2000-2022*

### 5. Analysis of research hotspots

Keywords are a distillation of the subject matter of the literature and the frequency of keyword clustering is directly proportional to the hotness of the research topic (see Figure 3). With the help of visualisation software, the clustering relationship and frequency of keywords can be visualised and the research hotspots in this field can be analysed. The focus formed two main clusters.

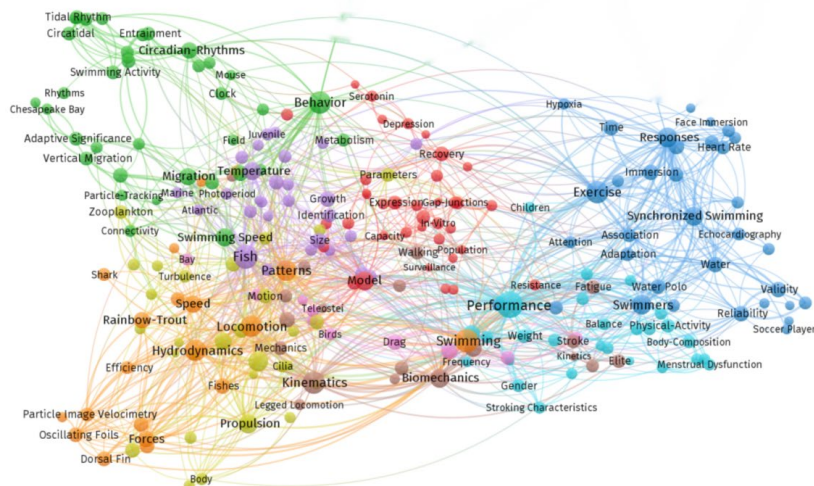


Figure 3: Keyword clustering diagram in the field of international synchronized swimming research in 2000- -2022

### 5.1 Cluster 1: a cluster set composed of keywords as "EXERCISE", "electrocardiography", "heart rate" and "hypoxia"

The cluster mainly studies the impact of synchronized swimming on athletes' physical skills. Different from swimming, synchronized swimming requires athletes to have solid swimming skills, but also requires athletes to master some difficult technical movements, which requires higher requirements for athletes' physical skills. Scholars Naranjo, J, et al<sup>[1]</sup>The experimental method is used to explore the activation of the respiratory compensation mechanism of synchronized swimmers when they perform difficult movements in the water and find that apnea in the water can cause functional respiratory adaptation in the body. Scholars Schaal, Karine, et al<sup>[2]</sup>We studied the effects of whole-body low temperature stimulation (WBC) and comparative water therapy (CWT) on the metabolic parameters of synchronized swimmers after training, and found that whole-body low temperature stimulation (WBC) had the most obvious effect on the recovery of synchronized swimmers after training. Scholar Ferrand, C, et al<sup>[3]</sup>Through comparative experiments, we explored the importance that synchronized swimming athletes and other athletes attach to their body appearance. The study found that synchronized swimmers have more negative feelings about their appearance, but they do not care about how others evaluate their appearance. Synchronized swimming requires constant underwater adjustment and suspended breathing, scholars Rodriguez-Zamora, L, etc<sup>[4]</sup>Examined 17 effective synchronized swimmers in the game 30 single and double movements when the perception of force score, heart rate, lactate peak and immersion parameters direct relationship, the results show that synchronized swimming competition intense dynamic movement and repeated apnea will cause certain damage to the athlete body.

### 5.2 Cluster 2: a cluster set composed of keywords such as "Migration", "Swimming Speed" and "Rhythms"

This cluster mainly explores the training mode, training effect and synchronized swimming events of the judges of synchronized swimmers. Scholars Badau, Adela, et al<sup>[5]</sup>The influence of the development of athletes on the synchronized swimming technique is explored through experimental methods. Scholars Winiarski, Slawomir, et al<sup>[6]</sup>The dynamic asymmetry index (DAI) was used to assess the standard degree of movement in synchronized swimmers. Synchronized swimmers need to perform more difficult technical movements in the water, which puts forward higher requirements for the core strength of the athletes, scholars Tinto, Amalia<sup>[7]</sup>We explored the influence of the pause training method on the stability of the core strength of synchronized swimmers, and found that this method can effectively enhance the stability of the core muscle group of synchronized swimmers. With the development of information technology, there are more and more cases of combining information technology and sports, scholars Ponciano, Katia Regina, etc<sup>[8]</sup>Through the study, it is found that using the training video of synchronized swimming competition can effectively improve the accuracy of

synchronized swimming referee judgment, and the video of synchronized swimming event is a reliable tool to train the referee of synchronized swimming event. Synchronized swimming is very significantly different from other swimming events, where athletes need to immerse their faces underwater for a long period of time. Thus the scholar Alentejano, Teresa et al<sup>[9]</sup>Through the study, it was found that the underwater immersion time of athletes in synchronized swimming events in Canada did not exceed 40s, and the referee score was not higher than the underwater immersion time. Scholar Cui, Zhihao<sup>[10]</sup>Through experimental research, it was found that the body training performance of synchronized swimmers is positively correlated with the stability of their core muscles, and the stability and endurance affect the performance to a large extent.

### 5.3 Cluster 3: a cluster set composed of keywords like "Model", "Surveillance" and "Serotonin"

This cluster mainly explores the effects of nutritional supplements and stimulants on synchronized swimming events. Swimming is the disaster area of various drugs; Scholar Mandic, Gordana Furjan<sup>[11]</sup>Questionnaires were given to 82 synchronized swimmers from Croatia and Serbia, and 28 coaches, aiming to investigate the knowledge of doping among athletes and coaches. Through the questionnaire information collected, it was found that older athletes and coaches would not have doping behavior in the future, and young athletes had a trend of doping behavior in the future. Similarly, highly educated athletes are not prone to doping, while less educated athletes are otherwise. Synchronized swimmers, especially those participating in team sports, need to strictly control their body shape. Studies have shown that some synchronized swimming appears eating disorders, irregular menstruation and other conditions. Athletes for the scholar Lundy, Bronwen<sup>[12]</sup>We analyzed the nutritional intake requirements of synchronized swimmers from the perspective of nutrition, and found that trace elements such as iron and magnesium are crucial for synchronized swimmers. Meanwhile, there is little research in this field, which needs to be combined with sports medicine and sports nutrition.

## 6. Analysis of the evolution trend of research hot spots

Keywords emergent detection is according to a certain year literature keywords frequency increases and detected, it can intuitively reflect a certain period of research hotspot, in order to more intuitive observation 2000-2022 international figure skating research evolution, using COOC software selection keywords frequency is greater than 5 of the first 10 emergent words draw the research hot spots emergent map. It can be seen from the keyword emerging map that the emerging word "Kinematics" as the emerging word first appeared in 2001 and continued to appear until 2002 (Figure 4). This mainly belongs to competitive sports compared with synchronized swimming, and sports, as the research object, is indispensable for research in this field. "Responses" as a emerging word first appeared in 2008, and the popularity continued until 2009, which is with scholars Bante, S, etc<sup>[13]</sup>The changes of lactate concentration after synchronized swimming were studied.

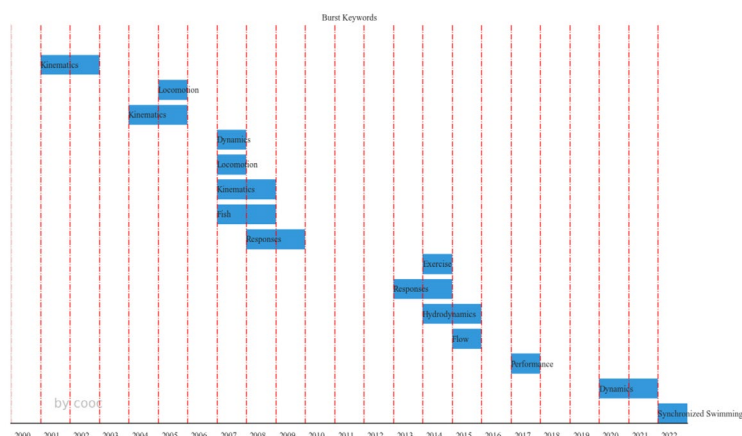


Figure 4: The evolution trend of international synchronized swimming research from 2000 to 2022

## 7. Conclusion

This paper uses COOC/VosViewer software and the metrology method to visually analyze the

literature on synchronized swimming published in the WOS database from 2000 to 2022, mainly analyzes the total number of articles, authors, cooperation, research hotspots and research evolution trends from 2000 to 2022, and draws the following conclusions:

According to the analysis of researchers in the field of international synchronized swimming in 2000-2022, it is concluded that the number of researchers from 2000-2022 is generally low, the direct cooperation intensity of researchers is not large, the cooperative relationship is not close, the inter-institutional cooperation is less, and the cooperation space among researchers needs to be improved. Therefore, in order to deepen the research in this field, a wide, close, interdisciplinary and cross-regional cooperation network should be established to strengthen the cooperation among researchers.

Through the analysis of key words in the field of 2000-2022, it is concluded that the research hotspot mainly focus on "Migration", "Exercise", "Performance" and other aspects.

In general, there is a large research space in the research field of international synchronized swimming, and researchers and research institutions in this field need to enhance the intensity and intensity of cooperation, and strengthen exchanges and cooperation. At the same time, we should provide new research ideas and research methods for international synchronized swimming with the help of interdisciplinary content.

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