Bibliometric Study on Sports Nutritional Supplements

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Abstract

Background: This study's objectives are to evaluate and report the current state of publications, authors, journals, nations, institutions, and keywords; investigate popular subjects and opportunities in the area; and suggest future directions for sports nutrition supplement research.
Methods: The relevant literature on sports nutrition supplements published globally between 1988 and 2024 was retrieved for this paper using bibliometric techniques and CiteSpace visualization and analysis software.
Results: This analysis comprised 527 papers in total, with the most published 133 coming from the United States. The most published institution was MDPI 91, and the most published authors were Stear, S J 49, Burke, L M 48, Castell, L M 47, Chen G P, and Tuan R S. After clustering, the majority of the high frequency keywords from each of the 25 papers were analyzed in parallel. Protein needs, ergogenic aids, endurance, and exercise emerged as the main research topics.
Conclusion: 1)An overall fluctuating upward trend was observed in the number of articles published in the study of sports nutrition supplements from 1988 to 2024, according to the number of articles published in the field. 2) The United States, Australia, and the United Kingdom have the largest concentration of research capacity, and there is a greater frequency of reciprocal research collaboration between the United States and nations like Australia, the United Kingdom, Brazil, Spain, etc. Burke, L. M., Castell, L. M., Stear, S. J.,etc. 3) As far as research hotspots go, researchers have recently concentrated on "supplements," "prevalence," "recovery," "sodium," and "sodium bicarbonate." "sports performance," "ioc consensus statement," "recovery," "sodium bicarbonate," "sports supplements," etc. Further research on the in-depth examination and use of functional sports nutrition supplements, the connection between intestinal health and sports nutrition supplements, the safety of sports nutrition supplements, and preventive medicine is anticipated in the future.

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1. Introduction

Sports nutrition supplements have gained a lot of attention as a significant way to improve athletic performance, encourage fatigue recovery, and boost physical immunity as a result of the ongoing advancements in sports science and people's growing health consciousness [1, 2]. With benefits ranging from energy supplementation to muscle growth, fatigue relief, fat reduction, and more, a wide variety of sports nutrition supplements have surfaced on the market in recent years[3, 4]. Athletes, fitness enthusiasts, and even researchers are now focused on how to choose and use these supplements scientifically and sensibly[5].

The mechanism of action, effect assessment, and safety of sports nutrition supplements have advanced significantly in previous research. The types and purposes of sports nutrition supplements have been continuously enhanced and improved [6], starting with the early supplementation of basic nutrients like proteins and carbohydrates [7, 8]and progressing to the later development of specific nutrients like vitamins D and E [9, 10], creatine [11], and branched-chain amino acids [12]. In the meantime, numerous researchers have used rigorous experimental design and scientific statistical analysis techniques to thoroughly examine how various supplements affect improving athletic performance, speeding muscle recovery, and encouraging body fat control [13]. This research offers solid theoretical support for the real-world use of sports nutrition supplements.

Nevertheless, the current study still has certain issues. 1) Due to variations in experimental design, sample selection, data processing techniques, etc., there are disparities and inconsistencies in the outcomes of various investigations [14]. 2) There is some evidence that sports nutrition supplements can enhance performance and speed up recovery [3, 4], however the precise impact varies according on the supplement type, dosage, and individual characteristics. 3) The effects and safety of several new sports nutrition supplements still need to be confirmed, and the study on them is not thorough enough and the updates are coming slowly[15, 16].

The cross-disciplinary science of statistically evaluating all knowledge carriers through statistical and mathematical techniques is known as bibliometrics [17, 18]. By combining qualitative and quantitative evaluations of particular items, bibliometrics can pinpoint study subjects and forecast future trends. Additionally, bibliometrics enables quantitative analysis of a certain area from several angles [19, 20] as well as a thorough examination of various nations, regions, institutions, journals, etc.[21, 22]. Sports, nutrition, and food have been the subjects of greater research on this methodology, although sports nutrition supplements have received less attention and have not been well examined.

In order to give researchers, athletes, and fitness enthusiasts in the field of sports nutrition supplements useful information, this study set out to thoroughly sort and analyze the research progress and trends of sports nutrition supplements based on CiteSpaceV (6.4.R1.64-bit. Advanced)software analysis, combined with the results of literature review and visualization analysis [23, 24]. It also proposed future research directions and suggestions in response to the

shortcomings and contentious points of the current research. It will give researchers, athletes, and fitness enthusiasts with useful reference material in the area of sports nutrition supplements. It will also offer theoretical references and helpful advice for future sports nutrition supplement research, development, and application.

2. Materials and Methods

2.1 Data source and search strategy

The Web of Science core database, which is acknowledged as an authoritative, comprehensive, and multidisciplinary database [25] and has emerged as the most popular database for bibliometric analysis [26], was used to confirm the data's rigor. 527 documents were included in the analysis after the search formula "topic=Sports nutrition supplement" was applied on November 27, 2024, to limit the article type to "Article &Review" and the language to "English." The literature span ended in December 2024. The chosen articles from the WOS database were exported as "plain text files," with the exported material containing "full record and cited references". The exported material is saved in the "download_1-500 and download_501-983" formats and contains "full record and cited references." Since the database is updated daily, all searches were finished on the same day, yielding 983 documents.

2.2 Criteria for inclusion and exclusion

By looking through the titles, abstracts, and keywords of the reviewed literature, journal articles on the subject of "sports nutrition supplements" were included. The last stage of the screening process was to identify and remove duplicates in order to guarantee the accuracy and completeness of the study data. Duplicates were examined manually, while the remaining data were input into CiteSpace and subsequently automated by the program's "Write Off Duplicates (WOS)" [27]. Two authors conducted the task of identifying irrelevant research by looking through the abstract, keywords, and title to find irrelevant literature. Secondary conversations were used to settle any disputes. Following each author's independent reading of the entire text, the findings were deliberated and determined. In order to create a comprehensive review of sports nutrition supplements, a sample of studies consisting of 527 legitimate publications was selected, as illustrated in Figure 1.
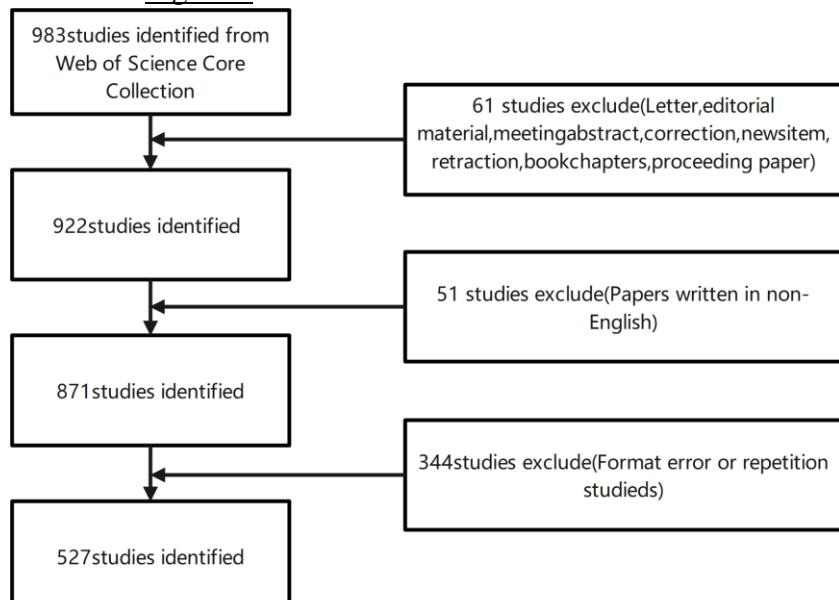

Figure 1. Flowchart of the inclusion criteria

2.3 Analysis tools

In order to measure the literature or collection of a particular knowledge area, Dr. Chao-Mei Chen developed CiteSpace, a visual analysis program [28, 29] that uses the Java language environment. In this paper, CiteSpace V (6.4.R1.64-bit.Advanced) was used. Prior to using the CiteSpace program, the following parameters were set: the time span was set to January 1988-December 2024, the time slice was set to one year, and the Top50 was chosen for analysis for each time slice. Nominal terms and LLR algorithms were extracted using keywords in the clustering labels, and the timeline changes and burstiness nodes of keywords were presented using the Timeline and Burstness approaches, respectively. The WPS program is used to statistically evaluate the running data and finish producing pertinent charts once the hotspots and development trends of sports nutrition supplement journals, nations, institutions, fields, authors, and keywords of the study have been sorted and summarized.

3. Result and Analysis

3.1 The Number and Pattern of Published Articles

After more than 30 years of development and evolution, an impressive development has been achieved, as evidenced by the changes in the number of publications, which reflect the level and degree of theoretical development of academic research in this field [30]. From 1988, when the first academic paper on sports nutrition supplements was published, to 2024, when 51 articles were published, significant progress has been made. A total of 1969 authors, 527 papers, 206 countries, 1592 institutions, and 184 journals were included in the study. The quantity of published articles might serve as an indicator of the field's present research tendencies and potential for future growth. A bar chart of the annual number of articles published in this study field was created based on the number of articles published on sports nutrition supplements each year (see Figure2), and it displayed a three-stage, generally fluctuating and growing pattern. Stage 1: Of the total number of samples, 81 articles were published in 2009 or earlier, making up 15.3% of the total. These articles were very few and in the early stages of development. Stage 2: From 2010 to 2018, the study of sports nutrition supplements grew quickly, with 167 publications totaling 36.7% of the sample. The amount of material produced was essentially constant each year, indicating a stable phase of development. Stage 3: The number of papers published has increased dramatically since 2019 and has remained over 35 annually, reaching 279 articles that make up 52.9% of the entire literature sample. This indicates a quick upward trend and a period of rapid development. The academic community will gradually pay more attention to the topic of sports nutrition supplements as people become more aware of how these supplements can improve physical fitness and athletic performance. As a result, the research in this area will become increasingly comprehensive.
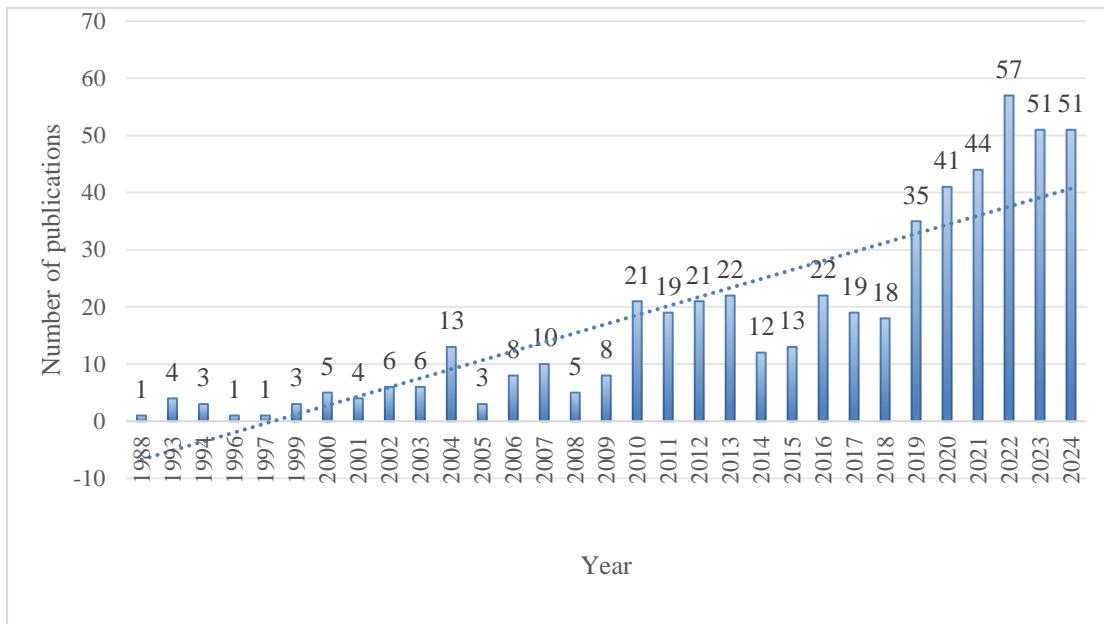
Figure 2. Annual number of publications and trends in sports nutrition supplements

3.2 Analysis of major journals

The sample literature on sports nutrition supplements was spread across 184 academic journals. The top 10 journals in terms of the number of articles published were primarily for nutrition, medicine, and sports-related journals (Table 1), with the British Journal of Sports Medicine (10.25%), International Journal of Sport Nutrition and Exercise Metabolism (7.21%), Journal of The International Society of Sports Nutrition (6.26%), Rbne-Revista Brasileira De Nutricao Esportiva (2.47%), Journal of Sports Sciences (2.47%), Strength and Conditioning Journal (2.28%), Progress In Nutrition (1.71%) and Frontiers In Nutrition (1.33%), and Sports (1.14%) having the highest impact factor.

Table 1. Sources of major journals in the field of sports nutrition supplements

Rank	Journal Names	Publications	% (N=527)	Impact Factors (2023)
1	Nutrients	62	11.76	4.8
2	British Journal of Sports Medicine	54	10.25	11.8
3	International Journal of Sport Nutrition and Exercise Metabolism	38	7.21	3.0
4	Journal of The International Society of Sports Nutrition	33	6.26	4.5
5	Rbne-Revista Brasileira De Nutricao Esportiva	13	2.47	0.2
6	Journal of Sports Sciences	13	2.47	2.3
7	Strength and Conditioning Journal	12	2.28	2.4
8	Progress In Nutrition	9	1.71	0.6(2021)
9	Frontiers In Nutrition	7	1.33	4.0
10	Sports	6	1.14	2.2

3.3 Author, Institution and Country Analysis
3.3.1 authors' analysis

The field's research level and direction are reflected in the core writers' research findings[31]. We can have a better understanding of the development direction of the sports nutrition supplement market by conducting a thorough examination of academics with expertise in the field. The emphasis on sports nutrition supplement research is relatively late, as Table 2 shows, with the most articles coming from reputable researchers for the first time in 2009 (Stear, S.J. 49, Burke, L.M. 48, Castell, L.M. 47). 4-8 only received a ranking of 57, indicating that there are still many prolific authors in the discipline. Research is still very much in progress.

Table 2. Top8 journals ranked by the number of publications

Rank	Number of publications	centrality	First release year	Author
1	49	0	2009	Stear, S J
2	48	0	2009	Burke, L M
3	47	0	2009	Castell, L M
4	17	0.02	2007	Burke, Louise M
5	15	0	2018	Dominguez, Raul
6	9	0	2021	Martinez-sanz, Jose Miguel
7	8	0	2021	Sospedra, Isabel
8	8	0	2011	Senchina, D S

Simultaneously, in CiteSpace software, authors are designated as the node type for analysis [32], facilitating a more intuitive and clear visualization of academic collaboration among high-productivity scholars. This allows for the generation of a core author cooperation network graph pertaining to scientific and popular journals relevant to the study, as illustrated in Figure 3. The runtime report indicates that there are 651 author nodes and 3024 connecting lines, with a Q-value of 0.4867. Notably, a larger font size for authors signifies a greater volume of published articles or increased activity. Analysis of the graph reveals that numerous scholars have engaged in academic collaboration, concurrently establishing a stable team comprising Stear, S.J., Burke, L.M., Castell, L.M., and other pivotal scholars. Consequently, the team exhibits a limited membership, with relatively weak collaboration and a narrow scope of cooperation.
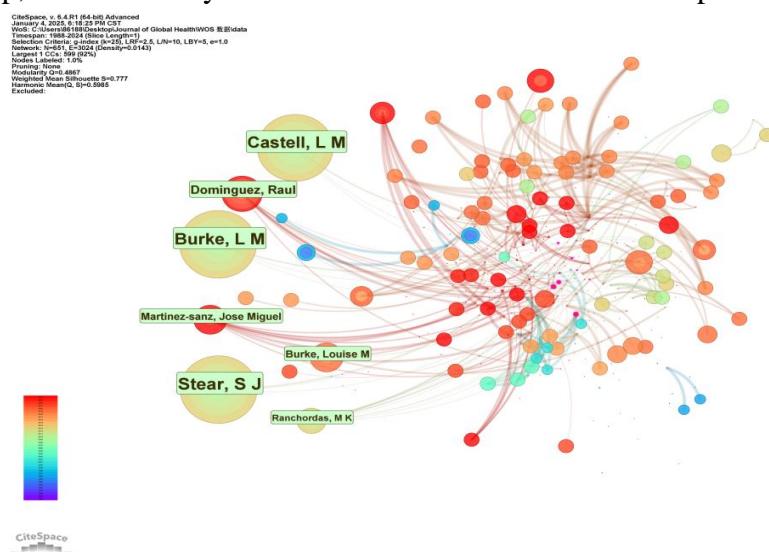

Figure 3. Collaborative co-occurrence map of highly productive authors of sports nutrition supplements

3.3.2 Institution analysis

The examination of the issuing institutions can reveal the mix of researchers and the allocation of academic resources in the domain [33], thereby identifying the social groupings genuinely invested in sports nutrition supplements.CiteSpace software was employed to examine the institutions of the valid samples, as illustrated in Figure 4, which depicts the distribution of institutions associated with research in sports nutrition supplement journals. Regarding inter-institutional cooperation, there exist 1023 connections among 423 nodes, resulting in a node density of 0.0115, which signifies inadequate inter-institutional collaboration and a necessity for enhanced cross-institutional cooperation. Larger circular nodes indicate a greater number of published papers, whereas the connections between nodes are illustrated by lines, with an increased number of lines signifying more collaborative publications [34].
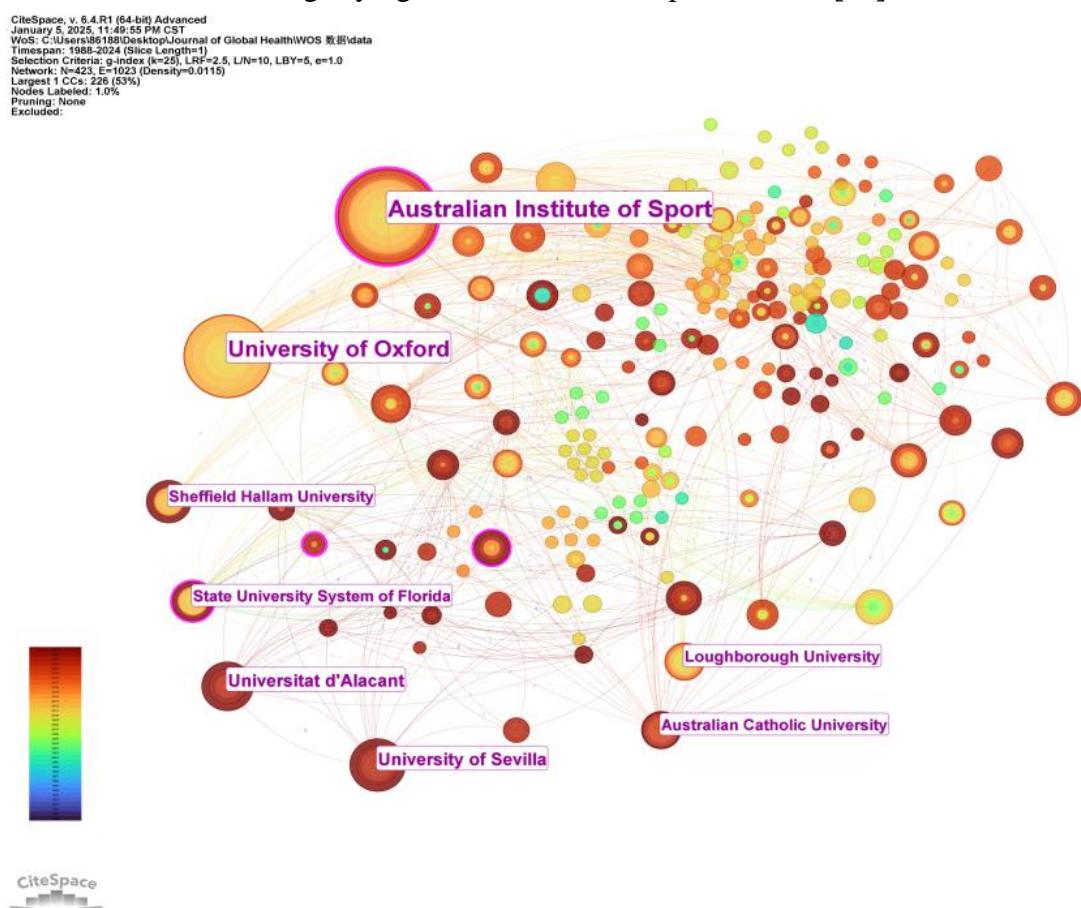
Figure 4. Distribution of sports nutrition supplement organizations

The analysis identified 527 articles associated with 113 research institutions, encompassing diverse topics such as editors and publishers, scientific research entities, colleges and universities, as well as governmental departments and social organizations. As illustrated in Table 3, institutions with 15 or more articles include MDPI (91 articles), Human Kinetics PUBL INC (45 articles), BMJ Publishing Group (42 articles), Lippincott Williams & Wilkins (25 articles), BMC (23 articles), Taylor & Francis LTD (22 articles), Taylor & Francis INC (16 articles), B M J Publishing Group, and INST Brasileiro Pesquisa & Ensino Fisiologia Exercicio-Ibpefex, each with 15 articles. Editorial and publishing organizations, along with scientific and popular research institutes, are unequivocally dominating in the volume of published papers and hold the status as study topics.

Table 3. Top 9 organizations in terms of number of articles issued

Rank	Institution Name	Number
1	MDPI	91
2	Human Kinetics PUBL INC	45
3	BMJ Publishing Group	42
4	Lippincott Williams & Wilkins	25
5	BMC	23
6	Taylor & Francis LTD	22
7	Taylor & Francis INC	16
8	B M J Publishing Group	15
9	INST Brasileiro Pesquisa & Ensino Fisiologia Exercicio-Ibpefex	15

3.3.3 Country analysis

The quantity of national publications indicates the level of research activity and contributions of various countries in a specific domain [35]. Comparing the quantity of papers published across various countries allows for the assessment of the significance and prominence of research in this domain within each nation [36]. Table 4 indicates that the United States leads in sports nutrition supplements research, contributing 133 studies, which constitutes 25.2% of the total output. Australia ranks second with 106 studies, while the United Kingdom follows in third place with 102 studies. Spain, Brazil, and Canada are next, with 62, 48, and 44 studies, respectively. These six nations produced 495 articles.

Table 4. Top 6 countries in terms of publications

Rank	Country	Number
1	USA	133
2	AUSTRALIA	106
3	ENGLAND	102
4	SPAIN	62
5	BRAZIL	48
6	CANADA	44

The geographical distribution map of countries illustrates academic research collaboration[30], as depicted in Figure 5, highlighting the robust connections between the United States and the United Kingdom, Australia, Canada, Brazil, and Spain. The robustness and density of connections among nations in Europe, North America, and Australia are especially significant. The extensive scientific collaboration enhances the production of scientific outcomes, with the United States maintaining cooperative ties with Canada, Australia, Italy, Brazil, China, the United Kingdom, Germany, and numerous other nations, underscoring its status as a leader in the discipline of sports nutrition supplements. A nation is considered a global hub of science if it generates over 25% of the world's total scientific output at any particular moment[37].
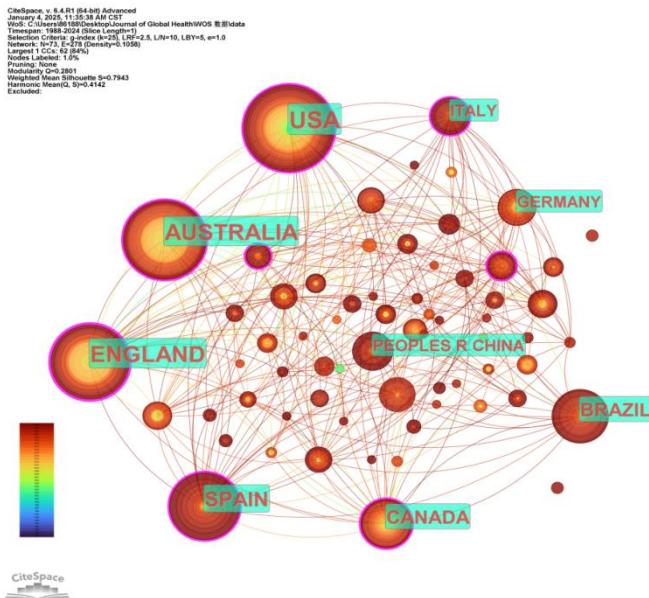
Figure 5. Main Research Countries for Sports Nutrition Supplements

3.4 Keyword analysis

3.4.1 Keyword cluster analysis

Keywords are succinctly derived from the article's content [38], encapsulating the prevailing topics in sports nutrition supplement research. Keyword clustering can reveal research hotspots in the field [26]. The cluster label indicates the current research direction. The Log-Likelihood Ratio (LLR) algorithm categorizes closely related keywords, with the number and size of clusters being inversely proportional to their dimensions [39] .The cluster numbers range from 0 to 12, representing the research intensity in descending order. Through cluster analysis of 525 keywords within the software, 13 clusters were identified, as illustrated in Figure 6. The keyword clusters pertaining to sports nutrition supplementation include: #0 parallel analysis, #1 ergogenic supplementation, #2 sports nutrition knowledge, #3 IOC consensus statement, #4 performance part, #5 nutritional intervention, #6 sports performance, #7 dietary supplement use, #8 athletic performance, #9 dietary-nutritional need, #10 metabolic stress, #11 energy, and #12 evaluation.Cluster #0 exhibited the most study intensity, focusing on sports nutritional supplements, which constituted the largest cluster. The cluster names frequently fail to accurately represent the exact specifics within the research hotspot, necessitating additional sub-clustering for more comprehensive analysis.
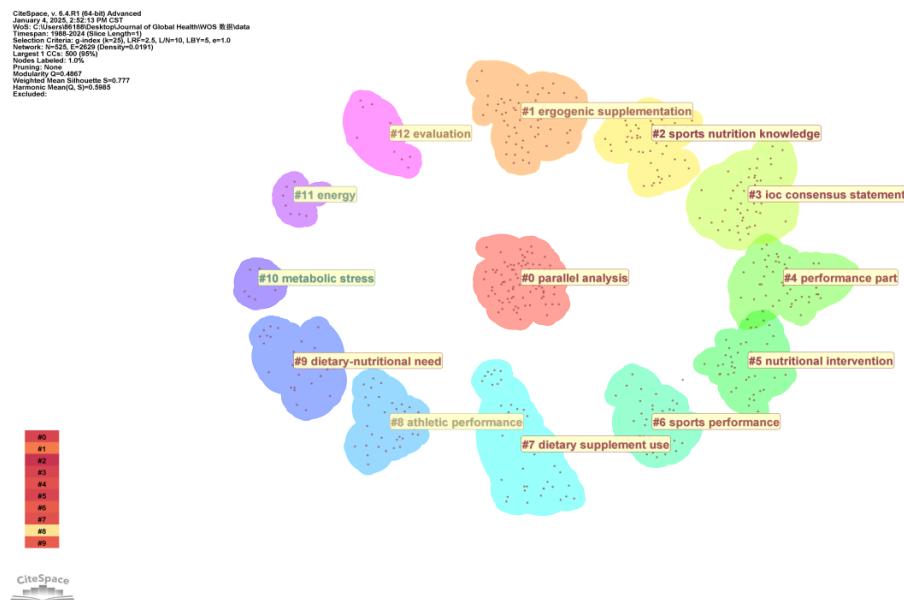
Figure 6. Cluster analysis of sports nutrition supplements keywords

3.4.2 Keyword clustering timeline view analysis

By organizing each cluster in chronological sequence based on the timing of keyword emergence, a timeline [40] is generated that illustrates the duration of the formation and evolution of each cluster, the research methodology, and the interconnections within clusters. Timeline analysis integrates the temporal dimension with keyword clustering, positioning the year of keyword occurrence on the horizontal axis and cluster labels on the vertical axis, thereby illustrating the progression of keywords within each time zone for each cluster, which reflects the research dynamism in the area [41]. The term clustering was examined in a timeline graph, revealing from Figure 7 that from 1988 to 2024, the study focus on sports nutrition supplements predominantly revolved on fundamental studies in sports nutrition, vitamins, nutritional understanding, and athletic performance. Since 2018, the focus of the study has shifted to athletes, with an increasing emphasis on nutritional supplementation, dietary nutrition, and sports nutrition. Clusters #1, #3, #5, and #7 represent the initial phases of research, with cluster #5's nutritional intervention studies being notably advanced, concentrating on the period from 1998 to 2015. Conversely, clusters #2, #4, #6, #9, and #11 commenced later, gaining scholarly attention regarding daily nutritional requirements in 2013, consistently leading research efforts and exemplifying the impending diversification trend in sports nutrition supplements.
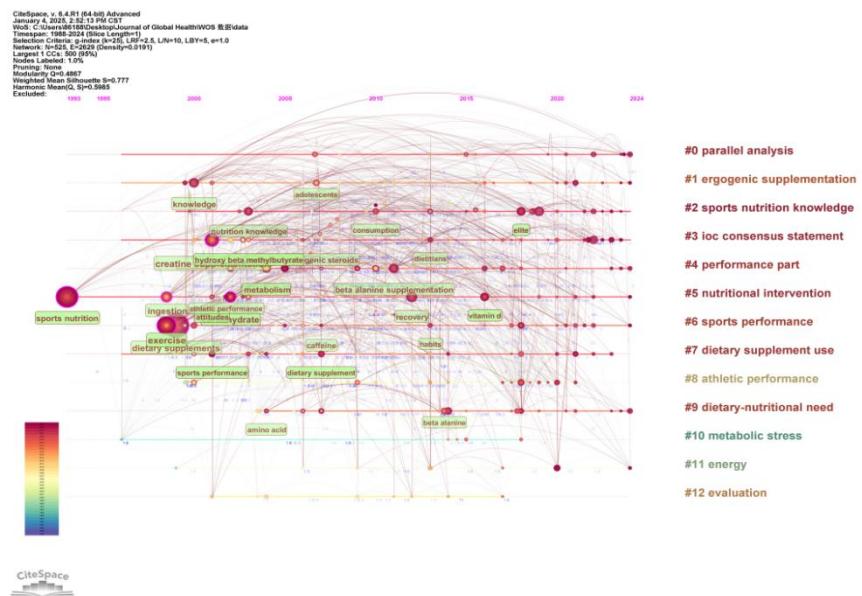
Figure 7. Keyword clustering timeline graph

3.4.3 Emergent keywords

An emergent keyword signifies a substantial alteration in a keyword variable over a brief timeframe and is regarded as a marker of a research frontier or an evolving developmental trend that materializes over time [42, 43]. Figure 8 illustrates 25 emergent phrases in the domain of sports nutrition supplements from 1988 to 2024, specifically "protein requirements." "ergogenic substances" "perseverance""endurance," "exercise," "resistance training," "muscle protein synthesis," "body protein synthesis," and "exercise." "muscle protein synthesis" Body composition, 2000-2005 'Protein needs' was progressively supplanted by alternative mutations. The term "protein requirements" has been progressively supplanted by emerging terminology, with 'supplements' gaining prominence from 2019 until the present. "prevalence" "recovery," "sodium bicarbonate," "athletic performance." "IOC Consensus Statement" "Sports Supplements" "are areas of significant research interest. The keyword exhibiting the greatest intensity is "exercise" at 5.2, succeeded by "prevalence" and "elite" with intensities of 4.88 and 4.2, respectively. The word with the lowest frequency was "efficiency," exhibiting a burst intensity of 2.26. The research subjects in sports nutrition supplements encompass protein requirements, ergogenic aids, endurance, and energy. These topics exhibited a burst intensity of 5.2, while "prevalence" and "elite" followed with intensities of 4.88 and 4.32, respectively. Endurance and exercise represent the developmental trajectory of the sports nutrition research domain in the preceding period.

Keywords	Year	Strength	Begin	End	1988 - 2024
protein requirements	2000	2.42	2000	2005	
ergogenic aids	1994	2.49	2002	2006	
endurance	2005	3.38	2005	2012	
exercise	1999	5.2	2007	2013	
resistance exercise	2010	4.18	2010	2012	
muscle protein synthesis	2010	2.88	2010	2012	
body composition	1999	2.69	2010	2012	
exercise performance	2002	2.46	2010	2012	
efficacy	2002	2.26	2011	2013	
strength	2005	3.39	2015	2016	
health	2003	3.25	2015	2018	
vitamin d	2016	3	2016	2017	
nutritional supplements	2005	3.19	2017	2019	
elite	2018	4.32	2018	2021	
dietary nitrate supplementation	2018	2.76	2018	2019	
2000 m rowing performance	2018	2.37	2018	2019	
supplements	2019	3.49	2019	2024	
consumption	2010	2.59	2019	2020	
sports	2016	2.5	2019	2020	
prevalence	2018	4.88	2020	2024	
recovery	2012	3.45	2020	2024	
sodium bicarbonate	2021	2.82	2021	2024	
sports performance	2001	2.36	2021	2024	
ioc consensus statement	2022	3.33	2022	2024	
sports supplements	2005	2.72	2022	2024	

Figure 8. Keyword emergence analysis

4. Discussion

Sports nutrition supplements are nutritional supplements created for fitness enthusiasts or athletes [44] in order to improve athletic performance , encourage muscle repair, and increase physical performance[45]. In recent years, there has been a lot of scientific research on the relationship between sports and nutrition, and the wise choice and application of sports nutrition supplements can assist athletes or fitness enthusiasts in performing better in sports. Furthermore, it is anticipated that future studies on sports nutrition supplements will focus on the following three areas due to the rise in consumer demand for nutritional supplements and the ongoing growth of the sports nutrition supplement industry.

4.1 Creation and implementation of customized sports nutrition products

The creation of tailored sports nutrition supplements for particular demographics (such as gender, age, and exercise level) has emerged as a key area of future research due to the rise in customer demand for individualized nutrition. Custom nutritional supplement solutions can be created by precisely matching each person's nutritional demands using big data analysis and artificial intelligence technology [46]. Supplements that are high in joint health elements, for instance, can be created for the older fitness population; supplements that aid in weight management and muscle repair can be launched for female athletes [47].

4.2 New developments in plant-based supplements for sports nutrition

As vegetarianism and veganism have gained popularity, the market for plant-based sports nutrition supplements has expanded significantly [46]. Future studies might concentrate on creating a greater range of plant-based supplements [48, 49], like novel goods that combine hemp or pea proteins with algal omega-3. In-depth research on the precise impacts of plant-based substances on sports performance is also required in order to provide scientific evidence for their efficacy.

4.3 Studies on the connection between gut health and sports nutrition supplements

An athlete's or fitness enthusiast's general health is significantly influenced by their gut health [50]. Future research should examine how various sports nutrition supplements affect the gut microbiota and how supplementing can improve gut health and boost athletic performance [51]. For instance, researching how supplements like probiotics and plant extracts can help athletes or fitness enthusiasts better absorb nutrients, reduce inflammation, and lessen fatigue by

modulating the gut flora [52, 53].

4.4 Studies on the safety of supplements for sports nutrition

One of the main concerns has been the safety of sports nutrition supplements. Long-term health impacts, toxicological examination, and ingredient analysis have been the primary areas of focus [50, 54]. It's critical to make sure supplements are clean and devoid of dangerous ingredients, as well as to specify the right dosage and possible adverse effects for certain demographics (such as professional athletes, fitness enthusiasts, and teenagers)[45]. The same supplement may have rather varied effects on different persons due to individual variances. Important steps to guarantee their safety include tighter market regulation and higher production standards for supplements [55]. To ensure that the supplements improve athletic performance without endangering human health, researchers, regulatory bodies, producers, and consumers must work together in a methodical effort to investigate the safety of sports nutrition supplements [16, 56].

5. Conclusions

CiteSpace was used in this study to metrologically, statistically, and visually analyze 527 sports nutrition supplement-related publications from the Web of Science database between 1998 and 2024. The annual publication volume of these publications, authors, institutions, countries, keyword clustering, and emerging keywords were all thoroughly examined, and the following findings were reached: 1)An overall fluctuating upward trend was observed in the number of articles published in the study of sports nutrition supplements from 1988 to 2024, according to the number of articles published in the field. 2) The United States, Australia, and the United Kingdom have the largest concentration of research capacity, and there is a greater frequency of reciprocal research collaboration between the United States and nations like Australia, the United Kingdom, Brazil, Spain, etc. Burke, L. M., Castell, L. M., Stear, S. J.,etc. 3) As far as research hotspots go, researchers have recently concentrated on "supplements," "prevalence," "recovery," "sodium," and "sodium bicarbonate." "sports performance," "ioc consensus statement," "recovery," "sodium bicarbonate," "sports supplements," etc. Further research on the in-depth examination and use of functional sports nutrition supplements, the connection between intestinal health and sports nutrition supplements, the safety of sports nutrition supplements, and preventive medicine is anticipated in the future.

6. Limitations

Only the literature from the Web of Science core integrated database was searched for this study; no literature from other databases was included, and other kinds of literature sources—such as conference abstracts, letters, books, etc.—were not included. The article types that were chosen to cover a limited number of data sources were reviews and articles. In order to provide a broad overview of the subject, the study primarily examined published articles, journals, authors, institutions, nations, and keywords; some crucial information was left out. The data is only collected in English; there is no comparative analysis with other nations, and neither multidimensional analysis nor data integration—which can also offer a theoretical foundation for the research of sports nutrition supplements—are present.

Author Contributions

Conceptualization: Guangxin Cheng, Hechong Yang. Data curation: Guangxin Cheng. Formal analysis: Guangxin Cheng. Investigation: Guangxin Cheng. Methodology: Guangxin Cheng. Software: Guangxin Cheng, Hechong Yang. Visualization: Guangxin Cheng. Writing - original draft: Guangxin Cheng, Hechong Yang, Writing -review & editing: Guangxin Cheng.

Data Availability
No/Not applicable.
Funding
Institutional review board statement:
Not applicable.
Informed consent statement:
Not applicable.
Data availability statement:
Not applicable.
Conflict of interest:
The authors declare no conflict of interest.

References
[1]G. Paulsen,H. Hamarsland,K. T. Cumming,R. E. Johansen,J. J. Hulmi,E. Børsheim,H. Wiig, I. GartheT. Raastad.Vitamin c and e supplementation alters protein signalling after a strength training session, but not muscle growth during 10 weeks of training.Journal of Physiology.2014;592(24),5391-5408.https://doi.org/10.1113/jphysiol.2014.279950

[2]Yayi Wang.Analysis of the law of sports nutrition development in china based on data mining.Food Saf.J.2024;02),126-131+153.https://doi.org/10.16043/j.cnki.cfs.2024.02.046

[3]Ye TaoWenqiang Wu.Research hotspots and trends in the relationship between sport and nutrition: A bibliometric analysis from 2013 to 2023.Medicine.2024;103(16),e37782.https://doi.org/10.1097/md.0000000000037782

[4]L. Wu,J. Liu,W. Huang,Y. Wang,Q. ChenB. Lu.Exploration of osmanthus fragrans lour.'S composition, nutraceutical functions and applications.Food Chemistry.2022;377(131853.https://doi.org/10.1016/j.foodchem.2021.131853

[5]Rosa Anna Siciliano,Anna Reale,Maria Fiorella Mazzeo,Stefano Morandi,Tiziana SilvettiMilena Brasca.Paraprobiotics: A new perspective for functional foods and nutraceuticals.Nutrients.2021;13(4),1225.https://doi.org/10.3390/nu13041225

[6]Julie Richards,Mary Beth Arensberg,Sara Thomas,Kirk W. Kerr,Refaat HegaziMichael Bastasch.Impact of early incorporation of nutrition interventions as a component of cancer therapy in adults: A review.Nutrients.2020;12(11),3403.https://doi.org/10.3390/nu12113403

[7]James P. White,Jacob M. Wilson,Krista G. Austin,Beau K. Greer,Noah St JohnLynn B. Panton.Effect of carbohydrate-protein supplement timing on acute exercise-induced muscle damage.Journal of the International Society of Sports Nutrition.2008;5(1-7.https://doi.org/10.1186/1550-2783-5-5

[8]Q. Goh,C. A. Boop,N. D. Luden,A. G. Smith,C. J. WomackM. J. Saunders.Recovery from cycling exercise: Effects of carbohydrate and protein beverages.Nutrients.2012;4(7),568-584.https://doi.org/10.3390/nu4070568

[9]Oriana D'ecclesiis,Costanza Gavioli,Chiara Martinoli,Sara Raimondi,Susanna Chiocca,Claudia Miccolo,Paolo Bossi,Diego Cortinovis,Ferdinando Chiaradonna,Roberta Palorini,Federica Faciotti,Federica Bellerba,Stefania Canova,Costantino Jemos,Emanuela Omodeo S

ale,Aurora Gaeta,Barbara Zerbato,Patrizia GnagnarellaSara Gandini.Vitamin d and sars-cov2 infection, severity and mortality: A systematic review and meta-analysis.PloS One.2022;17(7),1-24.https://doi.org/10.1371/journal.pone.0268396

[10]Claire E. Hastie,Daniel F. Mackay,Frederick Ho,Carlos A. Celis-Morales,Srinivasa Vittal Katikireddi,Claire L. Niedzwiedz,Bhautesh D. Jani,Paul Welsh,Frances S. Mair,Stuart R. Gray,Catherine A. O'donnell,Jason M. R. Gill,Naveed SattarJill P. Pell.Vitamin d concentrations and covid-19 infection in uk biobank (vol 14, pg 561, 2020).Diabetes & Metabolic Syndrome-Clinical Research & Reviews.2020;14(5),1315-1316.https://doi.org/10.1016/j.dsx.2020.07.021

[11]Jose Antonio,Darren G. Candow,Scott C. Forbes,Bruno Gualano,Andrew R. Jagim,Richard B. Kreider,Eric S. Rawson,Abbie E. Smith-Ryan,Trisha A. Vandusseldorp,Darryn S. WilloughbyTim N. Ziegenfuss.Common questions and misconceptions about creatine supplementation: What does the scientific evidence really show?Journal of the International Society of Sports Nutrition.2021;18(1),13.https://doi.org/10.1186/s12970-021-00412-w

[12]K. Nosaka,D. Chapman,M. NewtonP. Sacco.Is isometric strength loss immediately after eccentric exercise related to changes in indirect markers of muscle damage?Applied Physiology, Nutrition, and Metabolism. Physiologie Appliquée, Nutrition et Métabolisme.2006;31(3),313-319.https://doi.org/10.1139/h06-005

[13]Milou Beelen,Rene Koopman,Annemie P. Gijsen,Hanne Vandereyt,Arie K. Kies,Harm Kuipers,Wim H. M. SarisLuc J. C. Van Loon.Protein coingestion stimulates muscle protein synthesis during resistance-type exercise.American Journal of Physiology-Endocrinology and Metabolism.2008;295(1),E70-E77.https://doi.org/10.1152/ajpendo.00774.2007

[14]M. K. Ranchordas,N. Burd,D. S. Senchina,L. M. Burke,S. J. StearL. M. Castell.A-z of nutritional supplements: Dietary supplements, sports nutrition foods and ergogenic aids for health and performance-part 29.British Journal of Sports Medicine.2012;46(2),155-156.https://doi.org/10.1136/bjsports-2011-090836

[15]Floris C. WardenaarDaan Hoogervorst.How sports health professionals perceive and prescribe nutritional supplements to olympic and non-olympic athletes.International Journal of Environmental Research and Public Health.2022;19(19),12477.https://doi.org/10.3390/ijerph191912477

[16]Mudhi Alali,Maream Alqubaisy,Mariam Nasser Aljaafari,Asma Obaid Alali,Laila Baqais,Aidin Molouki,Aisha Abushelaibi,Kok-Song LaiSwee-Hua Erin Lim.Nutraceuticals: Transformation of conventional foods into health promoters/disease preventers and safety considerations.Molecules.2021;26(9),2540.https://doi.org/10.3390/molecules26092540

[17]Haibin Chen,Wei Jiang,Yu Yang,Yan YangXin Man.Global trends of municipal solid waste research from 1997 to 2014 using bibliometric analysis.Journal of the Air and Waste Management Association.2015;65(10),1161-1170.https://doi.org/10.1080/10962247.2015.1083913

[18]Yunhua Wang,Qiaorong Liu,Yongcong Chen,Yaling Qian,Bei Pan,Long Ge,Qi Wang,Guowu DingJiancheng Wang.Global trends and future prospects of child nutrition: A bibliometric analysis of highly cited papers.Frontiers in Pediatrics.2021;9(633525.https://doi.org/10.3389/fped.2021.633525

[19]W. Hou,X. Li,Y. WenX. Du.Global research trends in skiing from 1974 to 2023: A bibliom etric analysis.Heliyon.2024;10(15),e35471.https://doi.org/10.1016/j.heliyon.2024.e35471

[20]A. Ninkov,J. R. FrankL. A. Maggio.Bibliometrics: Methods for studying academic publish ing.Perspect Med Educ.2022;11(3),173-176.https://doi.org/10.1007/s40037-021-00695-4

[21]Ran Zhang,Yan-Yan Li,Zhong-Biao Nie,Xue-Qin Zhang,Yan-Miao MaYong-Hui Wang.Sc ientometric analysis of kidney disease and gut microbiota from 2001 to 2020 based on we b of science.Medicine.2022;101(48),e32138.https://doi.org/10.1097/md.00000000000320 81

[22]Hongfang Xia,Liang WangHaihua Wang.Current research trends, hotspots, and frontiers o f medical nutrition therapy on cancer: A bibliometric analysis.Frontiers in Oncology.2023; 13(1170198.https://doi.org/10.3389/fonc.2023.1170198

[23]M. Li,B. Yu,H. Yang,H. He,N. Li,A. Lv,X. ZhouR. Gao.Trends and hotspots in research o n osteoporosis and nutrition from 2004 to 2024: A bibliometric analysis.Journal of Health, Population, and Nutrition.2024;43(1),204.https://doi.org/10.1186/s41043-024-00690-5

[24]Xueying CaoXiaomei Lin.Visualization and analysis of knowledge graph for international academic research on chinese wushu - a citespace analysis based on web of science core ensemble.J. Wuhan Sports Univ.2020;54(12),61-68.https://doi.org/10.15930/j.cnki.wtxb.2 020.12.009

[25]Wenzhong HuYun Xu.The published trend of studies on covid-19 and dietary supplement s: Bibliometric analysis.Frontiers in Immunology.2022;13(1065724.https://doi.org/10.338 9/fimmu.2022.1065724

[26]Zhiqing Liu,Dongmei WangYi Wang.Citespace global human bone marrow mesenchymal stem cell research hotspot and visualization analysis based on wos core database.J. Clin. Transfus. Lab. Med.2024;26(06),797-805.https://doi.org/

[27]Kuo Xu,Changxin Luo,Tianbi Lei,Shuchang LiuGuodong Zhang.Bibliometric analysis of wrestling research progress in the past century (1924-2024).Ido Movement for Culture-Jo urnal of Martial Arts Anthropology.2025;25(1),17-29.https://doi.org/10.14589/ido.25.1.3

[28]C. Chen,R. DubinM. C. Kim.Emerging trends and new developments in regenerative med icine: A scientometric update (2000 - 2014).Expert Opinion on Biological Therapy.2014; 14(9),1295-1317.https://doi.org/10.1517/14712598.2014.920813

[29]Z. Zhao,Y. Li,P. Wang,R. ZhangZ. Nie.Research hotspots and trends in the relationship be tween genetics and major depressive disorder: A scientometric analysis from 2003 to 202 3.Medicine (Baltimore).2023;102(51),e36460.https://doi.org/10.1097/md.000000000003 6460

[30]C. M. Chen.Citespace ii: Detecting and visualizing emerging trends and transient patterns in scientific literature.Journal of the American Society for Information Science and Techn ology.2006;57(3),359-377.https://doi.org/10.1002/asi.20317

[31]Yiying TaoYuheng Tao.Integrating aesthetic education in quality education: A bibliometric analysis of sustainable development perspectives.Sustainability.2024;16(2),855.https://d oi.org/10.3390/su16020855

[32]Jose A. Moral-Munoz,Enrique Herrera-Viedma,Antonio Santisteban-EspejoManuel J. Cobo.Software tools for conducting bibliometric analysis in science: An up-to-date review.Profesional De La Informacion.2020;29(1), e290103.https://doi.org/10.3145/epi.2020.ene.03

[33]Xun Wei,Yan Long,Chenchen Yi,Aqing Pu,Quancan Hou,Chang Liu,Yilin Jiang,Suowei WuXiangyuan Wan.Bibliometric analysis of functional crops and nutritional quality: Identification of gene resources to improve crop nutritional quality through gene editing technology.Nutrients.2023;15(2),373.https://doi.org/10.3390/nu15020373

[34]Yan Miao,Ran Liu,Yuepu PuLihong Yin.Trends in esophageal and esophagogastric junction cancer research from 2007 to 2016: A bibliometric analysis.Medicine.2017;96(20),e6924.https://doi.org/10.1097/md.0000000000006924

[35]R. Q. Yao,C. Ren,J. N. Wang,G. S. Wu,X. M. Zhu,Z. F. XiaY. M. Yao.Publication trends of research on sepsis and host immune response during 1999-2019: A 20-year bibliometric analysis.International Journal of Biological Sciences.2020;16(1),27-37.https://doi.org/10.7150/ijbs.37496

[36]Zhuo Hao,Anna M. Rallings,Vicky Espinoza,Pingping Luo,Weili Duan,Qidong Peng,Yang GaoJoshua H. Viers.Flowing from east to west: A bibliometric analysis of recent advances in environmental flow science in china.Ecological Indicators.2021;125(107358.https://doi.org/10.1016/j.ecolind.2021.107358

[37]Kai Yu,Lei Hao,Fan Bu,Yuanzhi Guo,Yaqi Duan,Rui Hu,Ji LuPeng Li.Knowledge structure and emerging trends of cognitive impairment induced by sleep deprivation: A bibliometric analysis based on citespace and vosviewer from 2000 to 2022.Medicine.2023;102(40),e34776.https://doi.org/10.1097/md.0000000000034776

[38]Gang Xu,Qian Yang,Qiang LiHongli Yu.Research of digital management on sport: An analysis of bibliometrics using citespace software.Medicine.2024;103(50),e40872.https://doi.org/10.1097/md.0000000000040872

[39]Yue Chen,Chaomei Chen,Zeyuan Liu,Zhigang HuXianwen Wang.Methodological functions of citespace knowledge graph.Sci. Res.2015;33(02),242-253.https://doi.org/10.16192/j.cnki.1003-2053.2015.02.009

[40]Feifei Huang,Lin Zhou,Yao Lu,Ruiwei Liao,Yan LiMing Li.Visualization and analysis of pm2.5 health effects, 2013 to 2023: Bibliometrics of pm2.5 and health effects.Medicine.2024;103(49),e40793.https://doi.org/10.1097/md.0000000000040793

[41]Xiaodong XieHongbo Zhang.Citespace-based visualization of chinese medicine against osteoporotic compression fractures.Chin. Med.Clin. Res.2023;15(15),10-17.https://doi.org/10.3969/j.issn.1674-7860.2023.15.002

[42]Xiaobin HuangGao Wu.Research review of frontier detection methods in subject fields.J.China Soc.Sci.Tech.Int.2019;38(08),872-880.https://doi.org/10.3772/j.issn.1000-0135.2019.08.011

[43]Lv Xiongce,Ye Tao,Jing Zhu,Yan JinLixia Wang.A bibliometric analysis from 2013 to 2023 reveals research hotspots and trends in the connection between sport and regenerative medicine.Medicine.2024;103(27),e38846.https://doi.org/10.1097/md.0000000000038846

[44]K. Auxzilia PreethiDurairaj Sekar.Dietary micrornas: Current status and perspective in food science.Journal of Food Biochemistry.2021;45(7),e13827.https://doi.org/10.1111/jfbc.13827

[45]Hyunkook Kim.The study of teenager athletes of nutrition supplement and nutrition knowledge level.Korea Sport Research.2007;18(6),749-760.https://doi.org/G704-001366.2007.18.6.144

[46]R. D. Burns,M. R. Schiller,M. A. MerrickK. N. Wolf.Intercollegiate student athlete use of nutritional supplements and the role of athletic trainers and dietitians in nutrition counseling.Journal of the American Dietetic Association.2004;104(2),246-249.https://doi.org/10.1016/j.jada.2003.11.013

[47]Heitor O. Santos,Scott C. ForbesMihnea-Alexandru Gaman.Editorial: Functional foods, supplements, and dietary approaches in sports and clinical nutrition.Frontiers in Nutrition.2023;10(1203477.https://doi.org/10.3389/fnut.2023.1203477

[48]Michael Jeitler,Maximilian Andreas Storz,Nico Steckhan,Dorothea Matthiae,Justina Dressler,Etienne Hanslian,Daniela A. Koppold,Farid I. Kandil,Andreas MichalsenChristian S. Kessler.Knowledge, attitudes and application of critical nutrient supplementation in vegan diets among healthcare professionals-survey results from a medical congress on plant-based nutrition.Foods.2022;11(24),4033.https://doi.org/10.3390/foods11244033

[49]Corina-Aurelia Zugravu,Adriana Macri,Nastasia BelcRoxana Bohiltea.Efficacy of supplementation with methylcobalamin and cyancobalamin in maintaining the level of serum holotranscobalamin in a group of plant-based diet (vegan) adults.Experimental and Therapeutic Medicine.2021;22(3),933.https://doi.org/10.3892/etm.2021.10425

[50]Saikat Mitra,Abdur Rauf,Abu Montakim Tareq,Shamima Jahan,Talha Bin Emran,Talukder Galeeb Shahriar,Kuldeep Dhama,Fahad A. Alhumaydhi,Abdullah S. M. Aljohani,Maksim Rebezov,Md Sahab Uddin,Philippe Jeandet,Zafar Ali Shah,Mohammad Ali ShariatiKannan R. R. Rengasamy.Potential health benefits of carotenoid lutein: An updated review.Food and Chemical Toxicology.2021;154(112328.https://doi.org/10.1016/j.fct.2021.112328

[51]Daniele Giuseppe Buccato,Hammad Ullah,Lorenza Francesca De Lellis,Maria Vittoria Morone,Danae S. Larsen,Alessandro Di Minno,Marcello Cordara,Roberto Piccinocchi,Alessandra Baldi,Agostino Greco,Salvatore Santonastaso,Roberto SacchiMaria Daglia.Efficacy and tolerability of a food supplement based on zea mays l., gymnema sylvestre (retz.) r. Br.Ex sm, zinc and chromium for the maintenance of normal carbohydrate metabolism: A monocentric, randomized, double-blind, placebo-controlled clinical trial.Nutrients.2024;16(15),2459.https://doi.org/10.3390/nu16152459

[52]Douglas Xavier-Santos,Marina Padilha,Giovanna Alexandre Fabiano,Gabriel Vinderola,Adriano Gomes Cruz,Katia SivieriAdriane Elisabete Costa Antunes.Evidences and perspectives of the use of probiotics, prebiotics, synbiotics, and postbiotics as adjuvants for prevention and treatment of covid-19: A bibliometric analysis and systematic review.Trends in Food Science & Technology.2022;120(174-+.https://doi.org/10.1016/j.tifs.2021.12.033

[53]Daniel Merenstein,Bruno Pot,Gregory Leyer,Arthur C. Ouwehand,Geoffrey A. Preidis,Christopher A. Elkins,Colin Hill,Zachery T. Lewis,Andrea L. Shane,Niv Zmora,Mariya I. Pe

trova,Maria Carmen Collado,Lorenzo Morelli,Gina A. Montoya,Hania Szajewska,Daniel J. TancrediMary Ellen Sanders.Emerging issues in probiotic safety: 2023 perspectives.Gut Microbes.2023;15(1),2185034.https://doi.org/10.1080/19490976.2023.2185034

[54]Etsuko Kobayashi,Yoko Sato,Keizo UmegakiTsuyoshi Chiba.Analysis of safety alerts associated with dietary supplements from japan and overseas.Food Hygiene and Safety Science.2018;59(2),93-98.https://doi.org/10.3358/shokueishi.59.93

[55]Darla Daniel O'dwyerSujatha Vegiraju.Navigating the maze of dietary supplements regulation and safety.Topics in Clinical Nutrition.2020;35(3),248-263.https://doi.org/10.1097/tin.0000000000000207

[56]Nigel Walker,Scott Auerbach,Mike Devito,Stephen Ferguson,Sreenivasa Ramaiahgari,Stephanie Smith-Roe,Suramya WaidyanathaCynthia Rider.New approaches addressing the challenge of evaluating safety of botanical dietary supplements.Toxicology Letters.2017;280(S39-S40.https://doi.org/10.1016/j.toxlet.2017.07.101