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Nutritional Research Mapping for Endurance Sports: A Bibliometric Analysis

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ABSTRACTS

The purpose of the study was to discover a mapping of nutrition science research for endurance sports published between 2012 and 2022. 989 relevant articles were collected from Google Scholar using the Publish or Perish reference manager application with three main keywords of "Nutrition", "Sport", Endurance". The research on nutrition science for endurance sports can be classified into six terms, including Endurance, Sport, Exercise, Nutrition, Endurance Sport, and Sports Nutrition. The term Endurance is associated with 126 links with a total of 1724 strong links, the term Sport has 119 links with a total of 1117 strong links, the term Exercise has 118 links with a total strong link of 791, the term Nutrition has 120 links with a total of 1067 strong links, the term Endurance Sport has 106 links with a total of 472 strong links and the term Sports Nutrition has 86 links with a total of 325 strong links. There is an interesting cycle in which the number of studies each year fluctuates several times: 2012 (78), 2013 (76), 2014 (84), 2015 (98), 2016 (86), 2017(90), 2018 (104), 2019 (111), 2020 (85), 2021 (125), 2022 (52). The results of this research visualization are presented to provide the most recent reference guide, with the hope of providing appropriate further research directions related to nutrition science for endurance sports.

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1. INTRODUCTION

Over the last decade, sports science has made very rapid progress in the fields of technology, methodology, and innovation (Jonvik *et al.,* 2022). Along with these developments, the application of nutrition science in sports activities was also growing. This can be seen from the increasing number of modifications in the application of nutritional science in various sports activities, including sports medicine, recreational sports, and achievement sports. Sports nutrition science plays an important role in athletes' performance (Bahri *et al.,* 2022). High-carbohydrate foods and drinks help muscles build and retain glycogen for energy. Protein-fortified foods help in protein synthesis in muscle cells and adapt to exercise. Micronutrients (vitamins, minerals, biologically active substances) in various forms and isotonic fluids help rehydrate and provide extra energy for the body. This development must be balanced with the progress of human resources in the field of sports nutrition.

Nutrition knowledge is an important component in meeting sports nutrition guidelines (Klein *et al.,* 2021). In this regard, it is critical for athletes to comprehend the fundamental science of sports nutrition to get more understanding when meeting their energy requirements. Although nutrition science is merely a supporting aspect of sports, it can have a substantial impact on athletes if used correctly (Maughan *et al.,* 2018). Therefore, research in the field of sports nutrition is required to ensure that its application is following the needs and objectives of the sports activity itself. The more research, the better for the development of sports nutrition science. However, the research conducted must adhere to the regulations and guidelines that should be in place, so that the results acquired are valuable for the progress of the sports sector.

Sports nutrition science sits at the confluence of various life science disciplines, including nutrition, clinical, medical, health, biomedical, exercise, and food science (Kiss *et al*., 2021). This situation requires special attention so that the existence of these interrelated fields of science can strengthen the existence of sports nutrition. Because if it is not addressed seriously, sports nutrition may be in a non-strategic position. As a result, its existence may not be seen as significant in the world of sports.

Due to its complex nature, researchers around the world have carried out various systematic studies and meta-analyses on various aspects of sports nutrition science (Close *et al.,* 2019; Kerksick *et al.,* 2018a; Trakman *et al.,* 2016; Robertson & Mountjoy, 2018; Grgic *et al.,* 2018). One of the studies was nutrition science for endurance sports. The number of athletes competing in endurance and ultra-endurance sports has increased significantly over the last five years. Athletes have a very difficult challenge in these types of sports. As a result, endurance sports athletes are more at risk for medical and nutritional problems than athletes in other sports (Martínez-Sanz *et al.,* 2020).

Endurance sports are becoming increasingly popular (Vitale & Getzin, 2019; Nikolaidis *et al.*, 2018; Masson & Lamarche, 2016; Koehler, 2020, Jeukendrup, 2014). With the increasing popularity of endurance sports, athletes of all levels are interested in finding ways to improve their performance through training and nutritional adjustments (Jeukendrup, 2011). From the various information that the authors get, the fulfillment of nutritional needs in endurance sports requires special attention. Meanwhile, what often happens now is that the regulation of athlete nutrition is very rarely included in the priority program of sports coaches. Whereas the athlete's nutrition program is as important as the tactical, technical, and physical training program. Nutrition management programs will be very useful and closely related to physical exercise programs. Therefore, the athlete's nutritional regulation program will adjust to the

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physical exercise program. In addition, nutrition programs have a profound impact on the body and affect all physiological processes, from how the brain works to how the way muscles respond to an exercise program. Even small adjustments to nutrition will produce changes which significant in health, training, and performance body. However, the interest of academics and researchers in research in nutrition science for endurance sports cannot be ascertained yet, this requires a very detailed analysis.

There are several ways to conduct an analysis of the development of a study, one of which is bibliometric analysis. The bibliometric tool kit provides a standard methodology for mapping the knowledge base of a particular field of science (Kiss et al., 2021). Another source states that bibliometrics is defined as an activity to measure or analyze literature using mathematical and statistical approaches (Royani & Idhani, 2018). The author found several research results using bibliometric analysis with the following titles, "Structure and trends of international sports nutrition research between 2000 and 2018: bibliometric mapping of sports nutrition science" (Kiss et al., 2021), "Science Mapping for Nutrition Education in Sports Recovery Research: A Bibliometric Analysis" (Bahri et al., 2022), " Bibliometric analysis of studies on coffee/caffeine and sport" (Contreras-Barraza *et al.,* 2021), " Bibliometric analysis of the publication activity of Russian scientific institutions in sports science for 2008-2018" (Smolina *et al.,* 2020), "Physical activity and aging research: a bibliometric analysis" (Möller *et al.,* 2016), " College Sport publication trends over 15 decades: A Bibliometric Analysis" (Sofyan & Abdullah, 2022), "The bibliometric analysis of the sustainable influence of physical education for university students" (Xu *et al*., 2021).

From the many studies on bibliometric analysis that the authors found, there were no studies that specifically analyzed research trends in the field of nutrition for endurance sports. Therefore, the purpose of this study is to find out the mapping of nutrition science research for endurance sports published in the period 2012 to 2022. The bibliometric analysis was carried out using the publish or perish application as a search engine for research data, then continued with the help of the VOSviewer application to be able to provide computational data from the variables used as research materials. After obtaining the data from the analysis, the results of the visualization of this research are presented to be able to provide appropriate further research directions related to nutrition science for endurance sports.

2. METHODS

The study uses bibliometric analysis to gain insights into the mapping of nutrition science research for endurance sports published in the period 2012 to 2022. The use of bibliometrics will help to explore and describe the existing scientific literature on the topic of sports nutrition for endurance sports. All data analyzed in this study are articles that have been published and indexed by Google Scholar. This determination is because the database on Google Scholar is open and free, so we can easily get the data. The search process is assisted by using the publish or perish application which is also a free and easy-to-use application. Then to analyze the collected article data, the researcher uses the VOSviewer application which can provide some information, especially mapping in the field under study.

The process of using the publish or perish application and VOSviewer is carried out by following the guidelines contained in the Al Husaeni & Nandiyanto article (Al-Husaeni & Nandiyanto, 2021). There are several stages carried out in this research, including:

2.1. Collecting research article data using the publish or perish application

The article data collected is indexed on Google Scholar using the keywords "Nutrition* AND Sport* AND Endurance*".

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2.2. Bibliometric raw data processing using Microsoft Excel application

The data generated from the publish or perish application is meta-data that requires processing before being analyzed by the VOSviewer application. The data that has been processed is then analyzed to obtain some information related to the purpose of the research.

2.3. Analyzing the computational mapping of bibliometric article data using the VOSviewer application

Data from the publish or perish reference manager application is then stored and analyzed using the VOSviewer application to obtain a computational mapping of research data.

2.4. Perform advanced analysis of computational mapping data

The computational mapping of the data was then analyzed according to the purpose of this study and to obtain various information needed for advanced research purposes. This VOSviewer application produces three visualizations, each of which provides different information, namely network visualization, which provides an overview of the link strength of the research network, and results, overlay visualization, which shows traces of research history and density visualization, which shows the density of the unit being analyzed.

2.5. Conclusion withdrawal

Discussion of the findings for concluding this study is no less critical because this conclusion will provide input to researchers and readers for the sustainability of research development in the field being researched now.

3. RESULTS AND DISCUSSION

3.1. Publication data search result

After searching the data in the Google Scholar database using the Publish or Perish reference manager application, 989 articles were found relevant to the study requirements. The information collected was article metadata in a Microsoft excel file containing data on Cites, Autors, Title, Year, Source, Publisher, ArticleUrl, CitesUrl, GSrank, QueryDate, Type, DOI, ISSN, CitationURL, Volume, Issue, StartPage, endpage, ECC, CitePerYear, CitesPerAuthor, AuthorCount, age, Abstracts, FullTextURL, and RelatedURL. Some of the data samples published and analyzed using the VOSviewer application are presented in **Table 1**, which are the top 20 articles with the most citations (when the data was taken) in 2012-2022. The most relevant article from the search strategy is presented in **Table 1.**

3.2. Nutritional science research developments for endurance sports

The other finding in this study is the acquisition of data on research developments in the field of nutrition for endurance sports which have been published in journals indexed by Google Scholar. Based on the information presented in **Table 2**, there are 989 relevant research articles published in the period 2012-2022, with the following details: 78 articles in 2012, 76 articles in 2013, 84 articles in 2014, 98 articles in 2015, 86 articles in 2016, 90 articles in 2017, 104 articles in 2018, 111 articles in 2019, 85 articles in 2020, 125 articles in 2021, and lastly in the current year when this article was written, in 2022 there were 52 articles published.

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Table 1. Nutritional Science Research Data for Endurance Sports in 2012-2022.

No	Authors	Title	Year	Cites
1	(Meeusen *et al.*, 2013)	Prevention, diagnosis and treatment of the overtraining syndrome: Joint consensus statement of the European College of Sport Science (ECSS) and the American	2013	1437
2	(Thomas *et al.*, 2016)	Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: nutrition and athletic performance	2016	1183
3	(Nieman & Wentz, 2019)	The compelling link between physical activity and the body's defense system	2019	892
4	(Maughan *et al.*, 2018)	IOC consensus statement: dietary supplements and the high-performance athlete	2018	871
5	(Kerksick *et al.*, 2017)	International Society of Sports Nutrition position stand: nutrient timing	2017	812
6	(Mountjoy *et al.*, 2018)	International Olympic Committee (IOC) consensus statement on relative energy deficiency in sport (RED-S): 2018 update	2018	763
7	(Jäger *et al.*, 2017)	International society of sports nutrition position stand: protein and exercise	2017	750
8	(Kerksick *et al.*, 2018b)	ISSN exercise & sports nutrition review update: research & recommendations	2018	732
9	(Norheim *et al.*, 2014)	The effects of acute and chronic exercise on PGC-1α, irisin and browning of subcutaneous adipose tissue in humans	2014	730
10	(Lloyd & Oliver, 2012)	The youth physical development model: A new approach to long-term athletic development	2012	678
11	(Kreider *et al.*, 2017)	International Society of Sports Nutrition position stand: safety and efficacy of creatine supplementation in exercise, sport, and medicine	2017	668
12	(Bratland-Sanda & Sundgot-Borgen, 2013)	Eating disorders in athletes: overview of prevalence, risk factors and recommendations for prevention and treatment	2013	447
13	(Cooper *et al.*, 2012)	Creatine supplementation with specific view to exercise/sports performance: an update	2012	434
14	(Schwellnus *et al.*, 2016)	How much is too much? (Part 2) International Olympic Committee consensus statement on load in sport and risk of illness	2016	422
15	(Burke *et al.*, 2017)	Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers	2017	400
16	(Volek *et al.*, 2015)	Rethinking fat as a fuel for endurance exercise	2015	362
17	(Helms *et al.*, 2014)	Evidence-based recommendations for natural bodybuilding contest preparation: nutrition and supplementation	2014	357
18	(Sundgot-Borgen *et al.*, 2013)	How to minimize the health risks to athletes who compete in weight-sensitive sports review and position statement on behalf of the Ad Hoc Research Working Group …	2013	354
19	(Guasch *et al.*, 2013)	Atrial fibrillation promotion by endurance exercise: demonstration and mechanistic exploration in an animal model	2013	350
20	(Trexler *et al.*, 2015)	International society of sports nutrition position stand: Beta-Alanine	2015	344

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3.2. Nutritional science research developments for endurance sports

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From the data found and presented in **Table 2**, in the last 10 years (2012-2022) the development of research in the field of nutrition for endurance sports has fluctuated. **Figure 1** visualizes the decline in research interest from 2012 (78 articles) to 2013 (76 articles), then gradually increased in 2014 (84 articles) and 2015 (98 articles). Then there was another decline in 2016 (86 articles), increasing again in the next three years in 2017 (90 articles), 2018 (104 articles), and 2019 (111 articles). There was a significant decrease in 2020, for only 85 articles. This is possible because the world was being hit by the COVID-19 pandemic which required the researchers' focus. The highest research in nutrition for endurance sports occurred in 2021 in the last ten years, with 125 articles successfully published.

Table 2. Nutritional Research Development Data for Endurance Sports.

Year	Number of Publications
2012	78
2013	76
2014	84
2015	98
2016	86
2017	90
2018	104
2019	111
2020	85
2021	125
2022	52
Total	**989**

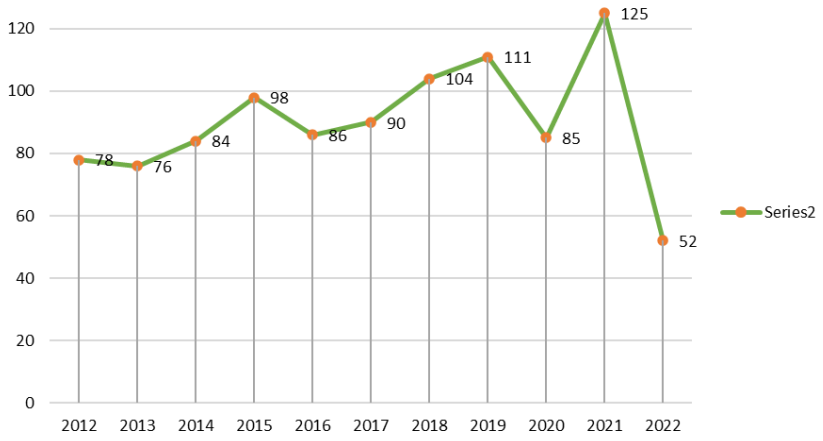

Figure 1. Nutritional Science Research Development Data for Endurance Sports.

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Meanwhile, a significant decline occurred in 2022. Until this October, the articles published had only reached 52 articles. From this explanation, research in nutrition science for endurance sports is still experiencing ups and downs and still requires much attention so that future scientific studies in this field will be carried out and can support scientific development.

3.3. Visualization of Nutrition Science Research Developments for Endurance Sports Using the VOSviewer Application

The articles collected from the Publish or Perish application are then analyzed with the VOSviewer application. The analysis resulted in 127 items of relevant and interrelated terms. These items have 3996 links and there are a total of 12323 strong links. This analysis also provides an illustration that each interrelated data item is divided into 5 different clusters, which are explained as follows:

(i) Cluster 1 (43 items): athlete, athlete, case study, coach, competition, cycling, cyclist, data, development, dietary intake, difference, distance, endurance athlete, endurance runner, endurance sport, energy, event, example, exercise metabolism, female athlete, female endurance athlete, hydration, hydration status, intake, international journal, knowledge, low energy availability, male endurance athlete, nutrition, nutrition knowledge, practice, prevalence, recommendation, relationship, relative energy deficiency, research, review, risk, runner, sleep, sport, sports nutrition, ultra-endurance.

(ii) Cluster 2 (28 items): Adaptation, age, body composition, cardiorespiratory endurance, change, comparison, day, diet, endurance training, factor, group, impact, influence, level, male, muscle, oxidative stress, physical activity, present study, rat, resistance, resistance training, subject, training, type, week, year.

(iii) Cluster 3 (23 items): addition, athletic performance, benefit, carbohydrate, elite endurance athlete, endurance exercise, endurance exercise performance, endurance performance, exercise, exercise performance, fatigue, female, hour, ingestion, international society, min, participant, protein, recovery, response, role, sports nutrition.

(iv) Cluster 4 (22 items): ability, aerobic endurance, caffeine, endurance, endurance capacity, improvement, individual, man, meta-analysis, muscle strength, muscular endurance, muscular strength, physical performance, placebo, power, speed, strength, supplementation, systematic review, time, trial, woman.

(v) Cluster 5 (11 items): dietary supplement, ergogenic aid, evidence, food, health, increase, nutritional supplement, part, sports performance, supplement, use.

Each of these clusters shows the relationship between the term items in it. In **Figure 2** can be seen that each cluster has a different color. This is to distinguish the links in each existing cluster. Then each term is given a circle label, and the size of the circle is distinguished based on the number of links that occur to that term (Nandiyanto *et al.,* 2021). The circle label is positively correlated with the occurrence of the search term in the abstract and article title (Nandiyanto & Al-Husaeni, 2021). The circle label gets bigger as the term is found. For more details, please see the following 2 images.

In addition to displaying the type of network visualization (network visualization) which will provide an overview of the strength of the link or the number of documents from the research network, the results of the VOSviewer analysis can also display 2 other types of views, namely overlay visualization which shows traces of research history and density visualization. visualization) which shows the density of the unit being analyzed (Hamidah *et al*., 2020).

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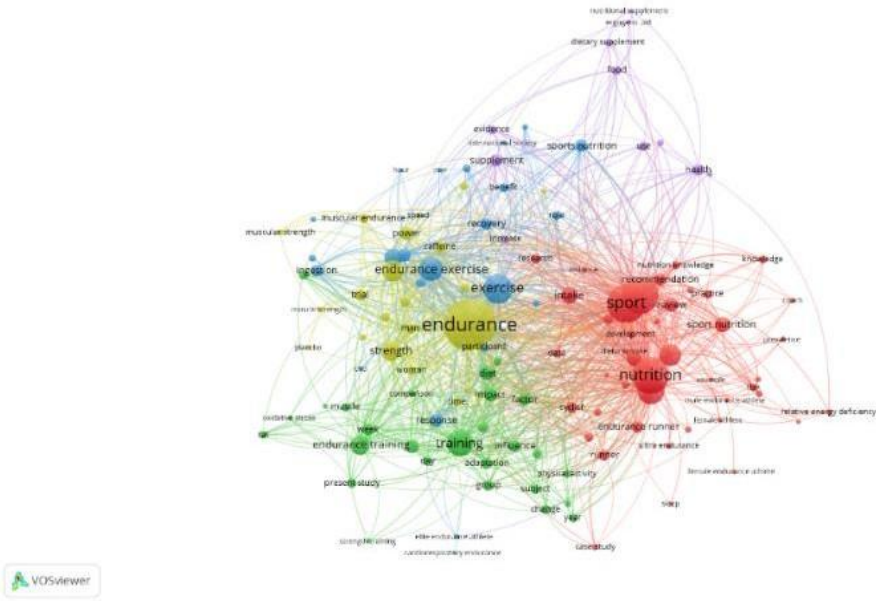

Figure 2. Network Visualization Nutrition for Endurance Sport.

As mentioned above, **Figure 3** is an Overlay Visualization that gives us an overview of the historical traces of research in the field of nutrition for endurance sports. The **Figure 3** shows that research in the field of nutrition for endurance sports was mostly carried out in 2016-2017. These data give us information that now is a good opportunity to make new research related to nutrition science for endurance sports because the popular time of this field has been happening for quite a long time.

Figure 4 gives us an overview of the density of research in the field of nutrition science for endurance sports. The clearer the visible yellow color, it indicates that the term is appearing more and more and is related to other terms. From the picture, we can see that the terms endurance, sport, and nutrition often appear and are related to other terms in nutrition research for endurance sports. Then the yellow color around the term fades, meaning that the term appears less and less in research articles related to nutrition science for endurance sports.

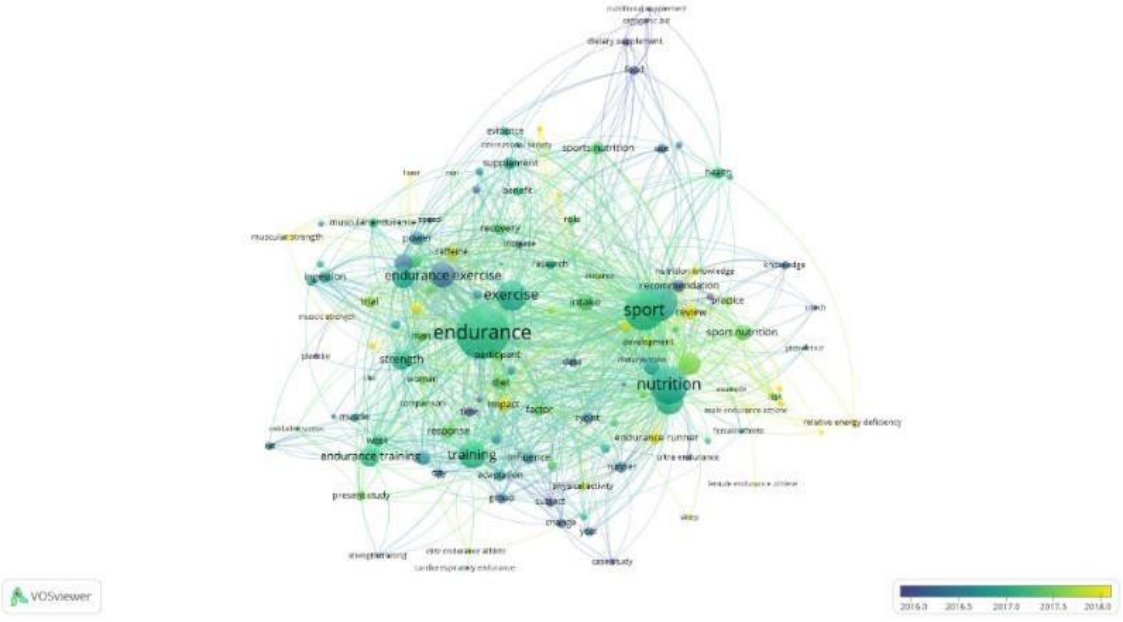

Figure 3. Overlay Visualization Nutrition for Endurance Sport.

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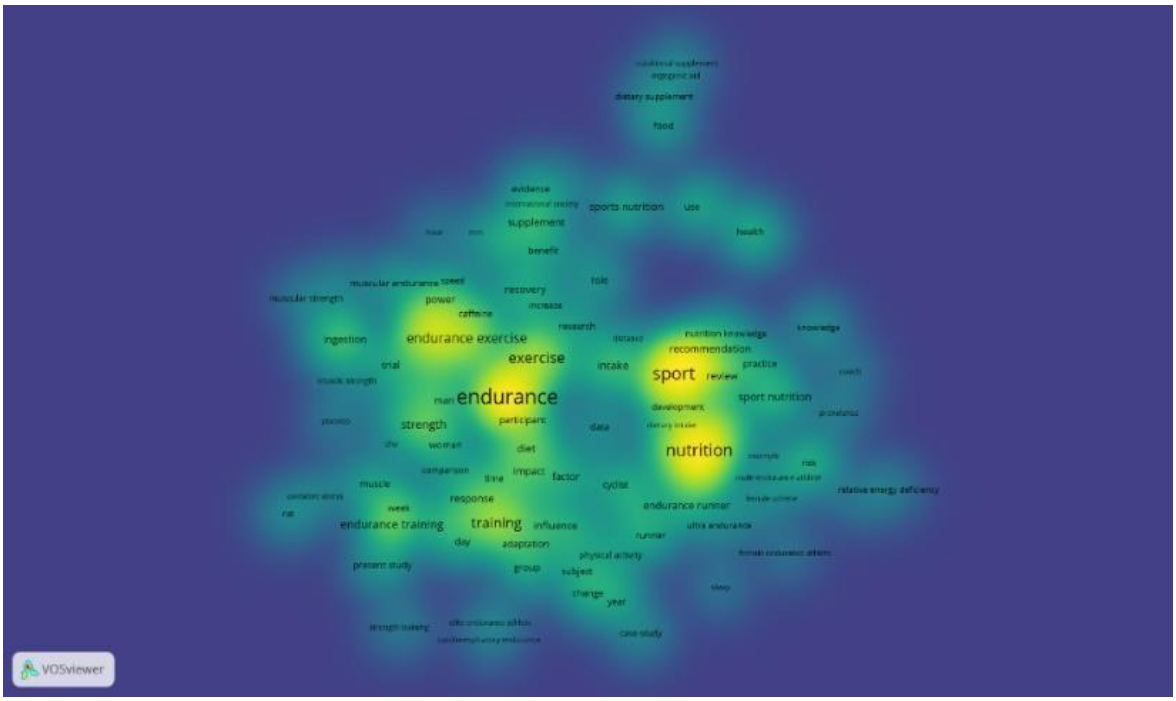

Figure 4. Density Visualization Nutrition for Endurance Sport.

From the results of the VOSviewer analysis, it can also be seen that in the period 2012-2022 research in the field of nutrition for endurance sports can be classified into 6 terms, namely, the term Endurance which has 126 links with a total of 1724 strong links **(Figure 5)**, the term Sport has 119 links with a total of 1117 strong links **(Figure 6)**, the term Exercise has 118 links with a total of 791 strong links **(Figure 7)**, the term Nutrition has 120 links with a total of 1067 strong links **(Figure 8)**, the term Endurance Sport has 106 links with a total of 472 strong links **(Figure 9)**, and the term Sports Nutrition has 86 links with a total of 325 strong links **(Figure 10)**. The following is a network visualization for each term:

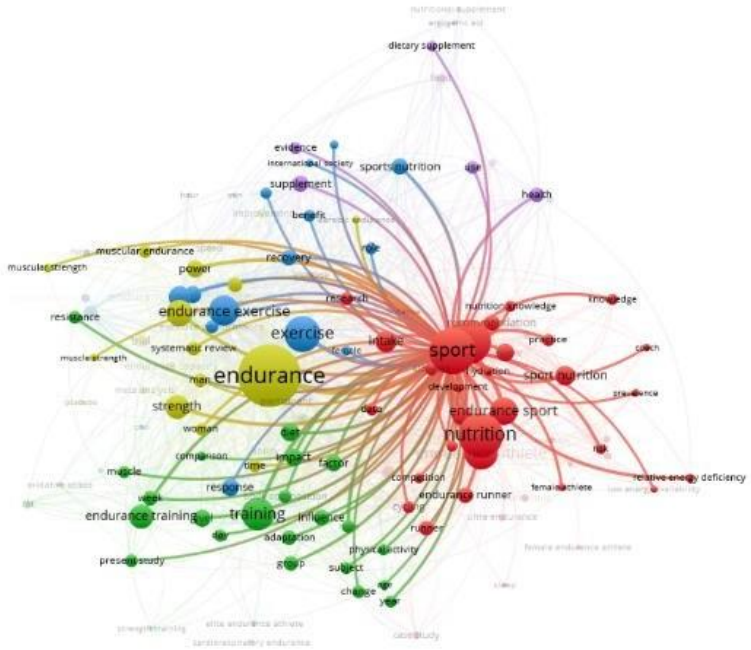

Figure 5. Network Visualization of Endurance Term.

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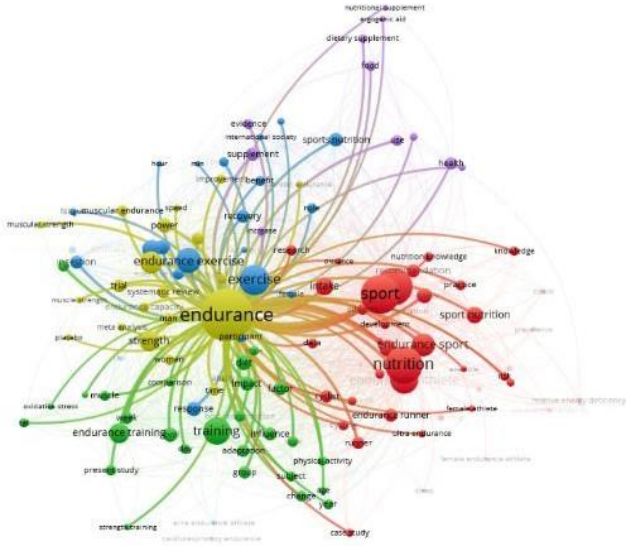

Figure 6. Network Visualization of Sport Terms.

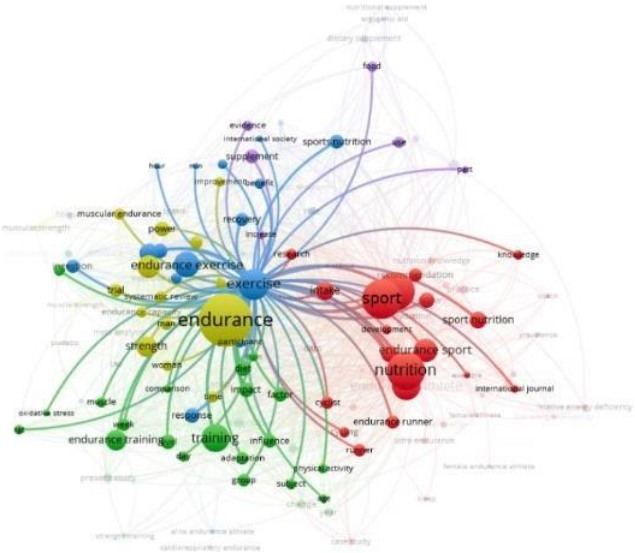

Figure 7. Network Visualization of Exercise Term.

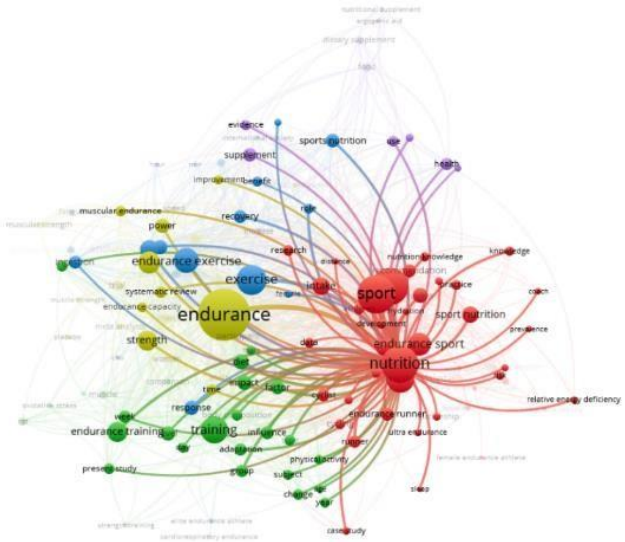

Figure 8. Network Visualization of Nutrition Term.

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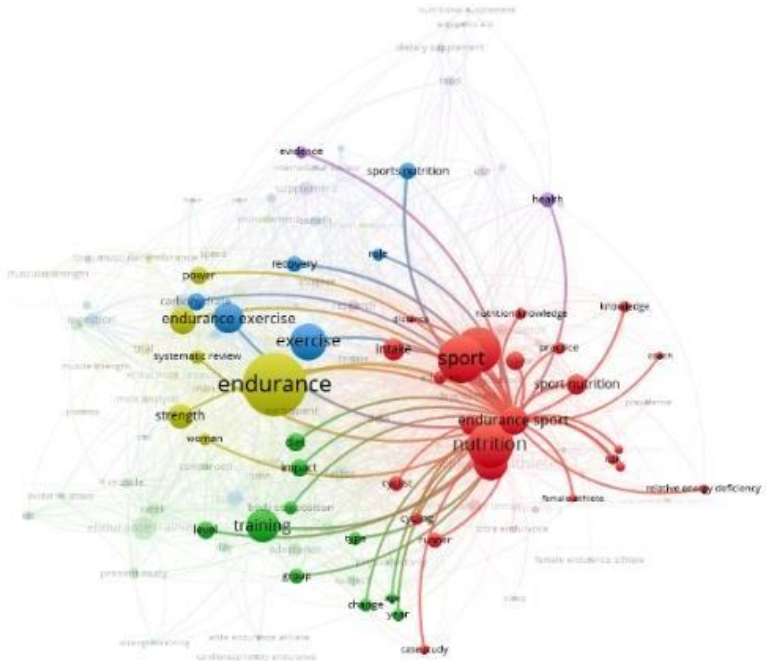

Figure 9. Network Visualization of Endurance Sport Term.

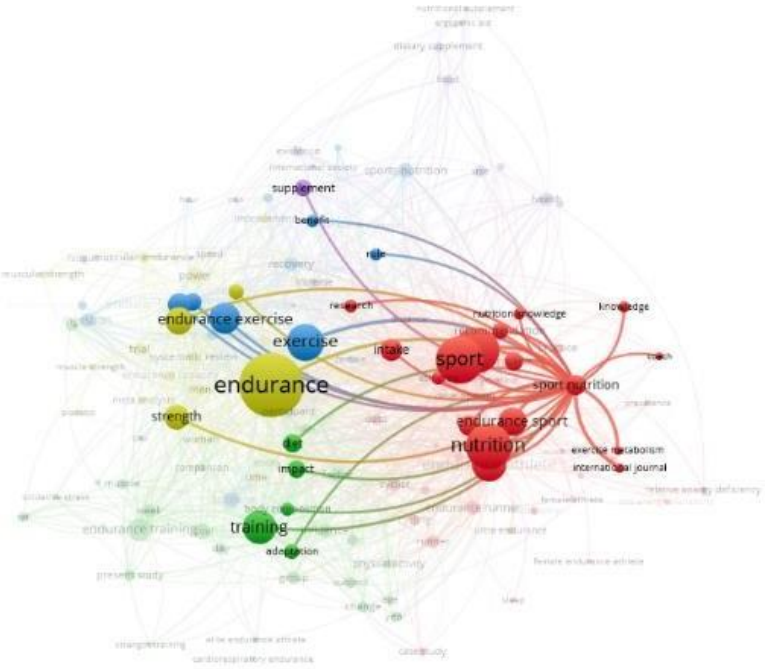

Figure 10. Network Visualization of Sports Nutrition Term.

Network visualization of each of the terms above gives us information that each term raised has a different link with other terms. This shows how often the term is used by previous researchers in research in the field of nutrition for endurance sports. The terms that are still rarely used are endurance sport and sports nutrition, which only have 106 links (for the term endurance sport) and 86 links (for the term sports nutrition). In contrast to the other 4 terms, it has 126 links (for the term endurance), 119 links (for the term sport), 118 links (for the term exercise), and 120 links (for the term nutrition). The conclusion we can draw is that the terms endurance sport and sports nutrition give us the opportunity to conduct a broader research novelty.

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4. CONCLUSION

The purpose of this study is to find out the mapping of nutritional science research for endurance sports published in the period 2012 and 2022. The keywords used are " Nutrition, Sport, Endurance" which are searched by Google Scholars based on the title and abstract in the publish or perish reference manager. Then the 989 articles found were analyzed using the VOSviewer application to obtain information that was the purpose of the research. The results of the analysis show that research in the field of nutrition for endurance sports has fluctuated several times, namely in 2014-2016, 2018-2020, and 2021-2022. Other results show that there are still many opportunities to develop research in the field of nutrition for endurance sports, especially by using the terms endurance sport and endurance sport. The conclusion was drawn because based on the analysis of the VOSviewer application, the two terms were still rarely used and linked with other terms. Thus, the novelty of research in the field of nutrition for endurance sports is still very possible to be developed.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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