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Sports and Nutrition: A Scientometric Review

K.H. Abdullah[1], D. Sofyan[2*], H.K. Kamaruddin[3] and E.U. Osiobe[4]

[1]*School of Business Management, Universiti Utara Malaysia, Sintok, Kedah, Malaysia*
[2]*Department of Physical Education, Universitas Majalengka, West Java, Indonesia*
[3]*Faculty of Sport Science and Recreation, Universiti Teknologi MARA, Arau Campus, Perlis, Malaysia*
[4]*Department of Business and Economics, Baker University, Baldwin City, United States*

Sports nutrition, a dynamic field, benefits competitive athletes. This study examines its evolution through Scopus and Web of Science trends. The authors employed ScientoPy software to analyse various publications, prominent sports (and) nutrition research areas, (pro)active authors in the field, keywords, popular sources, and institutional information. This study exploited the data reconciliation, cluster mapping, webmetric, and scientometric methodologies to analyse 1527 individual entries from the Scopus and Web of Science databases. These databases revealed that the most popular subject matters in the field were "sports nutrition" and "sport Science," with "sports nutrition" having the most 'keynoted' word in most nutrition and dietetics journals since 2019. "Muscle" is the second most popular subject matter in sports and nutrition, demonstrating its reputation in this study area, also experiencing a meteoric rise in popularity since 2019. Our findings showed the top five most popular keywords that gained traction (on a marginal analysis base) were "Sports nutrition," "Exercise," "Sports performance," "Nutrition," and "Dietary supplements." The study's contribution to sports and nutrition is that it grants readers and future researchers a spectrum of past and current sports nutrition trends. Also, the analysis from the study will help future researchers forecast potential industry trends.

Keywords: sports nutrition; cluster mapping scientometric; scientopy; Scopus; Web of Science

I. INTRODUCTION

Sports nutrition is a dynamic and ever-changing field of study in which both active individuals and competitive athletes benefit from improved sports nutritional standards or guidelines. A sports nutrition plan tailored to specific needs and goals is the foundation of athletic performance (Kerksick *et al.*, 2018). Individuals who are physically active or athletes will perform at their peak with the assistance of a well-planned diet (Abdullah *et al.*, 2022). Following a sports nutrition plan helps improve the body's hydration retention rate, maintain healthy immune function, and enhance concentration and stamina to train harder and longer (Vitale & Getzin, 2019). It thus facilitates the individual to consume the necessary food that would provide them with the needed energy, nutrients, and fluids. According to sports nutritionists, a well-balanced diet is essential for athletes who want to keep their bodies well-fuelled before, during, and after training (Arenas-Jal *et al.*, 2020; Ravindra *et al.*, 2020). Besides, it aids in the maintenance of fitness, toughness, and endurance during competitions (Potgieter, 2013). Significantly, sports nutrition can delay the onset of fatigue and improve muscle building and body repair when injuries are sustained.

In this study, sports nutrition is defined as the application of nutritional knowledge to a health plan to meet the dietary requirements for physical activity, optimise the refuelling process after physical exercise, improve athletic performance in training and competitions, and promote overall health and well-being (Fink & Mikesky, 2017). Sports nutrition research has been well-defined by studies that aim to improve understanding of nutritional physiology and generate the evidence base that underpins best practice guidelines (Burke *et al.*, 2018). Publications in the field of

*Corresponding author's e-mail: davisofyan@unma.ac.id

sports nutrition have increased exponentially over the last decade; however, athletes typically fail to follow the standards in their daily practice (Bentley *et al*., 2020). To establish an effective sports nutrition plan, researchers must meet the highest possible quality criteria (Bassaganya-Riera *et al*., 2021). It is crucial because sports nutritionists must assess the scientific merit of articles and advertisements about exercise and nutrition products to distinguish marketing hype from scientifically-based training and nutritional practices (Kadwe, 2020). Nutrition dosing regimens are inherently tricky, but unfortunately, they are frequently based on educated assumptions and marketing considerations rather than rigorous science (Nieman, 2021).

Food and fluids are the primary energy sources to sustain life and engage in physical activity (Feng *et al*., 2019). Specifically, carbohydrates, proteins, and fats contain macronutrients, which provide the energy necessary for healthy physiological function (Li *et al*., 2020). Nutritional deficiencies can harm performance, training, and recovery (Burke & King, 2012). In addition, a critical aspect worth emphasising is dietary requirements vary significantly before, during, and after exercise, depending on the intensity, duration, type of workout, body composition, and weather. Before training, glycogen synthesis and breakdown occur because exercise requires quick exogenous glucose absorption, insulin release, electrolyte replacement, and fluid retention (Ravindra *et al*., 2020). Nonetheless, rapid amino acid absorption, protein synthesis, muscle and tendon healing, inflammation reduction, and oxidative stress reduction are essential in the post-training phase because they help the body repair itself (Ravindra *et al*., 2020). Therefore, nutritional supplies that aid athletes with their metabolic and physiological needs and bolster their immune systems should be appraised.

Athletes primarily and deliberately use nutritional supplements to enhance performance, expedite recovery, prevent vitamin shortages, and maintain overall health. Many Saudi Arabian athletes invest in taking dietary supplements throughout the season, with 43.80% using them for performance and 32.60% believing in their health benefits (Aljaloud & Ibrahim, 2013). It is a fact that many athletes require a well-balanced diet to preserve health, growth, recuperate and improve athletic performance. Nevertheless, many athletes eat according to population trends rather than public health or sports nutrition guidelines (Meyer *et al*., 2007). This problem has arisen as athletes have several motives for selecting nutritional supplements that fit the supplement criteria in athletic performance (Fennell, 2004). In addition, the ubiquitous availability of dietary supplements in society is reflected in athletes' use of these items at all levels of competition. Consequently, athletes must be well-informed about sports nutrition to choose a diet that will help them perform at their best.

Nutrition education is thus one strategy for equipping athletes with the skills and discretion to be well-informed, which will assist them in eating a well-balanced diet to meet their sporting needs. Athletes can benefit from nutrition education and counselling by trained sports nutrition experts if their dietary habits, intake, and knowledge of sports nutrition are insufficient or incomprehensive (Danh *et al*., 2021). Athletes with a higher level of nutrition knowledge tend to consume more fruit, vegetables, and carbohydrate-rich foods than athletes with a low level of nutrition knowledge, implying that sports nutrition knowledge may be associated with an appropriate dietary intake (Alaunyte *et al*., 2015). A good understanding of nutrition is an essential determinant of dietary behaviour, and nutritional practices impact athletic performance (Trakman *et al*., 2018). Inadequate nutritional knowledge and misunderstanding of general and sports-specific nutrition concepts highlighted the need for nutrition education programs to improve athletes' healthy abilities (Rosi *et al*., 2020). In effect, the significance of a comprehensive understanding through sports nutrition education for athletes cannot be underestimated in ensuring the discretionary and responsible development of eating habits that include supplement intake and avoidance of substance abuse or alcohol.

By recognising the critical nature of sports nutrition research, this study employs a scientometric review to provide a comprehensive picture of sports nutrition. Unfortunately, there is still a shortage of scientometric or bibliometric reviews of sports nutrition research. Scholars have been enticed by the scientometric or bibliometric reviews of enteral nutrition application for: ventilator-

associated pneumonia (Chen *et al.*, 2019); nutraceuticals and functional foods (Yeung *et al.*, 2018); and wheat and barley research trends (Giraldo *et al.*, 2019). Nevertheless, these reviews relied on a single database, either Scopus or Web of Science (WoS). Furthermore, Abdullah *et al.* (2022) conducted a bibliometric analysis on sports nutrition exclusively utilising the Scopus database. Thus, the scientometric evaluation in this study is carried out using ScientoPy software and metadata from the Scopus and WoS databases. ScientoPy is a script-based Python tool for performing temporal scientometric analysis. This methodology can use temporal analysis to pinpoint the emergence of a new phenomenon and its progression to a trending or emerging issue (Ruiz-Rosero *et al.*, 2017).

The current study aims to (i) identify the publication growth and prominent research areas, (ii) conduct an analysis of the author's keywords and influential sports nutrition research, and (iii) recognise prominent sources and primary institutions in the field of sports nutrition. The authors believe that this article contributes to expanding knowledge about current trends in sports nutrition research by providing readers and future researchers with an overview of research conducted on the properties of this nutrition constituent.

II. MATERIALS AND METHOD

The study employs a scientometric method to analyse the growth and current trends in sports nutrition research by combining metadata from two well-known databases, Scopus and WoS. Using both Scopus and WoS for this study provides a more comprehensive and robust analysis of sports nutrition research. Each database has its own unique coverage of journals and publications and combining them allows for a more complete picture of the field. Despite the importance of sports, only a bit of scientometric analysis has been done to examine the dynamics of research and publication patterns on a global scale (Sofyan *et al.*, 2022). Scientometric, bibliometric, informetric, webometric, and cybermetric are metrics studies with slightly different concepts and applications. The terms refer to the dynamics of disciplines as they manifest themselves in their literary productions. The undertaking of a bibliometric review has gained popularity due to the extensive number of papers being published across many knowledge domains (Abd Aziz *et al.*, 2022).

Scientometric, for instance, is defined as a quantitative approach to analysing the development of science (Su & Lee, 2010). It is used to measure research impact, understand the citation process, map the knowledge structure and evolution using large-scale academic datasets (Zhong *et al.*, 2019). Furthermore, when conducting systematic reviews, performing a scientometric analysis can be a valuable source of information, especially when relevant and up-to-date systematic reviews are not readily accessible (Chen & Song, 2019).

Scientometric analysis of sports nutrition in this study is conducted using ScientoPy. ScientoPy is the software platform to manage the study's most important topics, authors, countries, and related publications. It is a free and open-source Python-based scientometric analysis tool that could eliminate bias in individual publications (Ruiz-Rosero *et al.*, 2017). ScientoPy script is capable of the following but not limited to: (i) obtain access to the Clarivate Web of Science and Scopus databases, (ii) sort publications according to document type, (iii) locate and eliminate duplicated documents, (iv) create a graph depicting the history of the most popular topics, (v) create a graph depicting the history of selected items within a topic, (vi) discover popular topics by examining the top average growth rate (AGR), and (vii) computing h-index for authors and countries.

A. Data Retrieval

The metadata in the current study was drawn on Scopus and WoS databases using institutional subscriptions on August 14, 2022. The data retrieval was initiated by recognising precise keywords, pertinent information, and the specific objective of the analysis. Sports nutrition metadata was collected using the keywords based on TITLE-ABS-KEY: "sport* nutrition", "exercise nutrition", performance nutrition", "sport* diet*", "sport* feed*", "sport* intake", and "sport* supplement*". Truncation or stemming with the asterisk (*) was employed to extend the search. It included alternative word ends and spellings and identified any paper containing all the fundamental concepts' derivations in the title, abstract, or keywords.

The PRISMA flow diagram was utilised to find, evaluate, and include papers for our review of bibliometric data. Figure 1 shows the approach for gathering Scopus and Web of Science (WOS) documents, which will subsequently be examined. This bibliometric review's main objective is to look at the publication trends in the Scopus and WoS database that are connected to sports nutrition. The research was finished in the context of descriptive analysis using the document checking method in the Scopus and WoS database.

B. Data Repossession and Management

Pre-processing was applied to the repossession data in this study. At this stage, ScientoPy processed data based on the following document types: (i) conference paper, (ii) article, (iii) review, and (iv) proceeding paper (Ruiz-Rosero *et al.*, 2017). The documents excluded from this study ranged from books, book series, and letters. Additionally, during the pre-processing step, ScientoPy normalised the author's name by replacing it with a semicolon for metadata retrieved from the Scopus database, stripping dots, commas, and special characters for metadata retrieved from both databases, and removing duplicated samples with the same title and authors (Pabon *et al.*, 2020).

The pre-process brief graph in Figure 2 shows the entire loaded documents for each database and the removed duplicated records. Based on Figure 2, the ScientoPy pre-processing script sets the WoS documents ahead of the Scopus documents; there were more documents from the WoS databases than the Scopus after the duplication removal. The raw source dataset used in this study included 4.065 papers and appended entries from the WoS and Scopus databases. This study had kept out 526 papers resulting from ScientoPy's automatic classification of publications as conference papers, articles, reviews, proceeding papers, and press articles, which yielded 4.627 papers. Following data reconciliation, this study worked with 2.605 individual entries from both databases, containing 1.949 unique papers from the WoS and 656 unique papers from the Scopus, with 22 duplicated papers from the WoS and 1.438 from the Scopus removed.

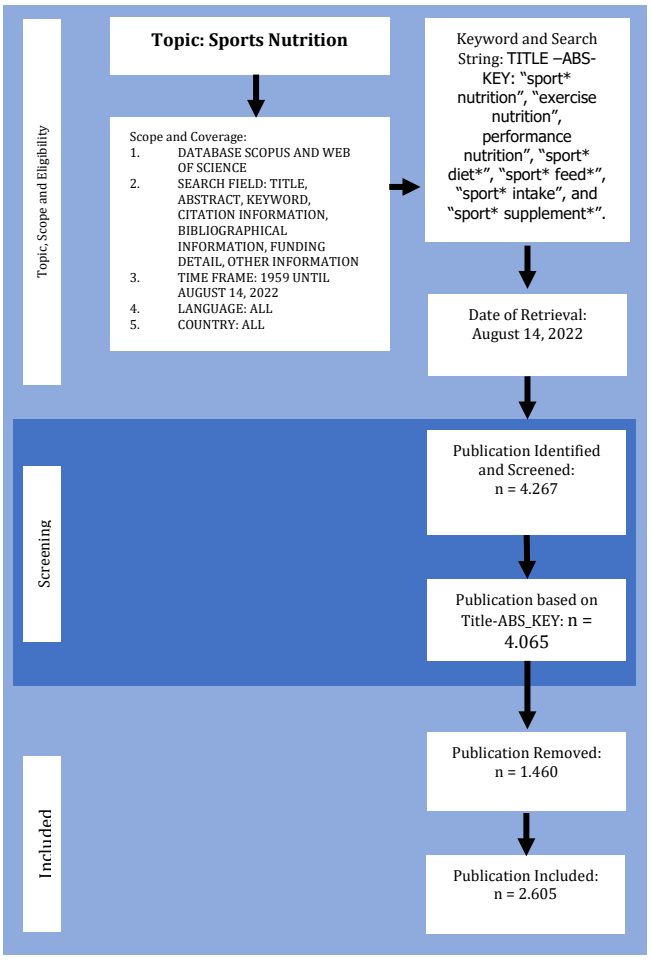

Figure 1. The PRISMA flow diagram was utilised to find, evaluate, and include papers for our review of bibliometric data

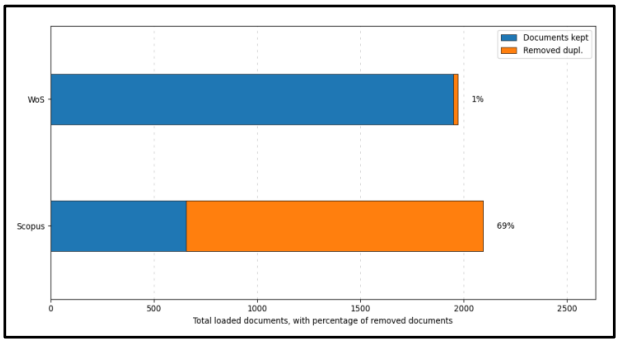

Figure 2. Pre-processing of data from the WoS and Scopus databases

III. RESULT AND DISCUSSION

Our analysis covered the period from January 1, 1990, until December 1, 2021. The year of initiation is pre-configured in the ScientoPy software by default.

A. Publication Growth and Prominent Subject Area

The evolution of sports nutrition publications in both databases is depicted in Figure 3. It demonstrates the remarkable direction in which this field has grown significantly since 2000. Additionally, the percentage of documents published in the last two years (2020 to 2021) specified that 22.40% were issued in the WoS and 22.04% in the Scopus.

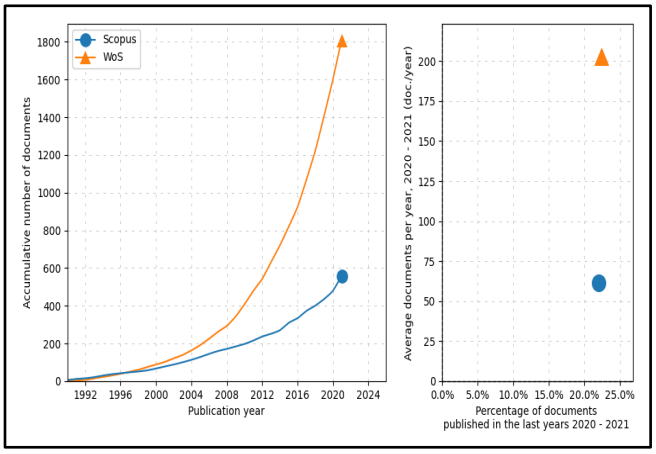

Figure 3. The evolution of sports nutrition publications in the WoS and Scopus databases

Figure 4 portrays the top ten prominent subject areas in sports nutrition, with Sport Sciences taking first place with 795 papers. Nutrition and Dietetics are ranked second (654 papers), and Public, Environmental & Occupational Health is ranked third (87 papers). In line with the current trend (2020 and 2021), sports nutrition has attracted 26% of the Nutrition and Dietetics publications. Other research areas that have published papers with more than 20% in 2020 and 2021 include Public, Environmental, and Occupational Health (31%), General and Internal Medicine (20%), and Pharmacology and Pharmacy (21%).

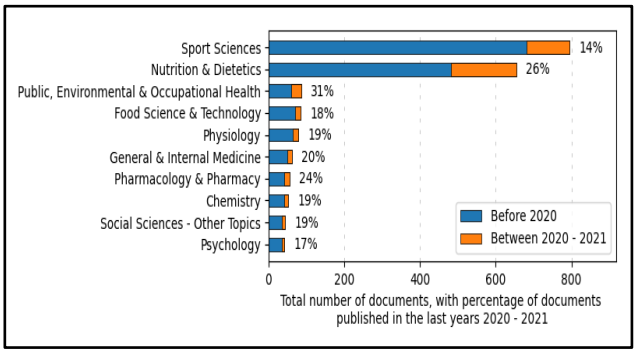

Figure 4. The top ten prominent subject areas in sports nutrition research

B. Author's Analysis

Table 1 shows the number of authors who frequently published on sports nutrition based on the extracted data from ScintoPy software. Total publications, Average Growth Rate (AGR), Average Documents per Year (ADY), Percentage of Documents in the Last Years (PDLY), and the author's h-index are all listed in the table.

Burke, L.M., Castell, L.M., and Stear, S.J. have actively published articles pertinent to sports nutrition. As of December 1, 2021, the authors have published more than 40 papers. It is crucial to note that these authors are not always first or correspondent authors. Likewise, they may be co-authors of a written article. Burke, L.M. is the most proactive author with 88 publications. The second and third most proactive authors are Castell, L.M. and Stear, S.J. The authors have published 45 and 44 papers related to sports nutrition.

In terms of PDLY, Antonio, J., were the authors that contributed to the highest percentages of published papers in 2020 and 2021. It is depicted that more than 15% of their publications were available in 2020 and 2021. Table 1 also displays the author's h-index, with Burke, L.M. ranking first with a similar h-index (25). The second-highest h-index is Kreider, R.B. (20). The third-ranked h-Index with 17 is Antonio, J. This study indicated that Burke, L.M. has the highest number of ADY with 5.05, followed by Antonio, J. with 1.05 ADY. In this study, Kreider, R.B. shared the third position of ADY with a contribution of 1.00.

Table 1. The top ten proactive authors on sports nutrition research

Rank	Author	Total	AGR	ADY	PDLY	h-Index
1	Burke, L.M.	88	01.05	05.05	12.05	25
2	Castell, L.M.	45	-0.5	00.00	00.00	10
3	Stear, S.J.	44	00.00	00.00	00.00	9
4	Kreider, R.B.	25	-0.5	01.00	08.00	20
5	Hoffman, J.R.	22	-0.5	00.00	00.00	13
6	Antonio, J.	20	-1.0	01.05	15.00	17

Note. AGR = Average growth rate; ADY = Average documents per year; PDLY = Percentage of documents in last years.

C. Keywords Analysis

Author keywords refer to the authors' chosen keywords to precisely describe a document's content. The authors' keywords aided readers, and future researchers locate crucial points in publications. Author keywords are used by many electronic search engines, databases, and journal websites to find relevant publications. In this case, ScientoPy might track the evolution of a study topic or search argument using the authors' keywords.

This section investigates the authors' primary keywords in previous research on sports nutrition. Research trends were discovered based on the authors' keywords to complete the workflow. It has been suggested that similar terms in American and British spellings and singular and plural keywords be combined. These manual exercises help with data organisation and avoid term duplication, resulting in more robust results.

Figure 5 illustrates 15 previously used keywords in prior research. The five most frequently used keywords, as exemplified in Figure 4, are "Sports Nutrition," "Exercise," "Nutrition," "Athletes," and "Ergogenic Aids." Although Figure 5 depicts the first 15 keywords, ScientoPy allows us to view an unlimited number of keywords. Figure 5 also illustrates the percentage of documents published in the previous years (2020–2021) as a measure of relative growth. This indicator shows that "Body Composition" was the 15th topic on this list but had the highest PDLY (38,03%).

This study's most renowned keyword is "sports nutrition." This keyword exists in 610 articles. Using ScientoPy's extended results, we could examine linked publications based on the authors' keywords. The article with the highest citations for this term was titled "*Effects of creatine supplementation on body composition, strength, and sprint performance*." This article was published in 1998 and has obtained 345 citations to date. This article was strongly related to the keyword "Exercise," used in 188 publications. The keyword "Exercise" has become the second most popular in this analysis. This keyword was applied in 168 publications to illustrate the content of the articles. The highest citation of an article that used this keyword was "*The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities*." This article was published in 2006 and accumulated 134 citations. The third popular keyword was "Nutrition." The most cited publication pertinent to this keyword was "*International society of sports nutrition position stand: nutrient timing*." This review paper, published in 2017, has received 233 citations. The fourth popular keyword was "Athletes," found in 125 publications. The most cited publication pertinent to this keyword was "*Low carbohydrate, high fat diet impairs exercise economy and negates the performance benefit from intensified training in elite race walkers*." This review paper, published in 2017, has received 213 citations. "Ergogenic Aids" was the fifth most popular keyword. The keyword has been associated with 120 previous publications. The publication with the most citations for this keyword is "*ISSN exercise & sports nutrition review update: research & recommendations,*" published in 2018 and has received 246 citations.

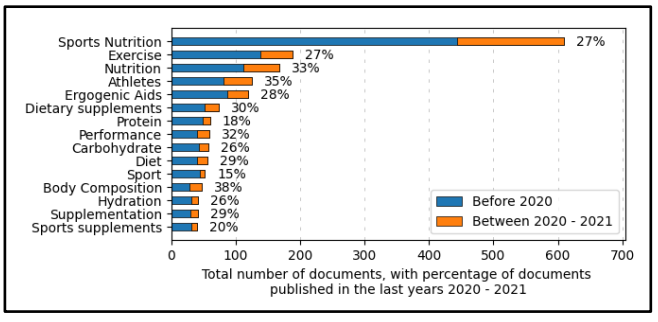

Figure 5. The top 15 authors' keywords on sports nutrition

This study used cluster mapping to identify themes or topics relevant to sports nutrition to determine the co-occurrence of authors' keywords. Mapping strategies are utilised by researchers to facilitate the analysis of pertinent material that is directly relevant to their research inquiries (Abdullah, 2021). A combination of Scopus and WoS metadata datasets was pre-processed with ScientoPy before generating a network map with the VOSviewer. Furthermore, this study used a thesaurus file to map the co-occurrence of the authors' keywords. Thesaurus files are essential for concatenating similar terms, spelling variations, and singular or plural terms like but not limited to Sports nutrition and Sport nutrition, endurance training and endurance exercise, and food consumption and food intake.

The frequency of keywords occurring in VOSviewer was proportional to the node's size (see Figure 6). The lines represented the nexus among keywords. The link strength of the nexus depended on the lines' thickness, which indicates the degree of co-occurrence. Figure 6 illustrates the authors' keywords in an overlay diagram, highlighting their links to other keywords through colour, node size, text size, and the thickness of connecting lines. This analysis's minimum number of keyword occurrences is 20; out of 4.181 keywords, 43 met this threshold. The diagram's red nodes indicated the most recently discovered terms, while the blue nodes represented previously explored terms.

The VOSviewer results enabled us to deduce that the most frequently used keywords in 2014 and 2015 were "Exercise" with (204 occurrences), "Ergogenic aids" with (130 appearances), "Sports supplements" with (79 occurrences), "Resistance training" with (32 appearances), "Supplements" with (32 occurrences), "Resistance training" with (31 appearances), and "Amino acids" with (39 occurrences). In addition, the strength of the keywords with "Sports nutrition" indicated that "Exercise" had (348 links), "Ergogenics aids" had (247 connections), "Athletes" (217 links), "Carbohydrates" (164 connections), "Protein" (129 links), and "supplementation" (86 links).

Publications between 2015 and 2016, the results of our cluster mapping showed most authors' keywords as follows: "Sports" (99 occurrences), "Physical activities" (46 appearances), "Nutritional supplements" (24 appearances), and "Antioxidants" (31 occurrences). With a link strength of 67, the connection between "Sports nutrition" and "Physical activities" was considered more significant during this epoch.

Compared to the other terms in the network, "Dietary supplements" was identified as the most commonly used keyword between 2016 and 2017, with (102 occurrences). The second most common keyword during this period was "Diet" with (61 appearances), followed by "Hydration" with (45 occurrences), and "Recovery" with (44 occurrences).

The most recent keyword that was initiated after 2017 was "Nutrition knowledge," with an occurrence of 39. This keyword had (56 links), with "Sports nutrition," "Athletic performance," & "Heath" (18 links), "Running" & "Supplements" (22 links), "Oxidative stress" (17 links), and "Questionnaire" (10 link strength).

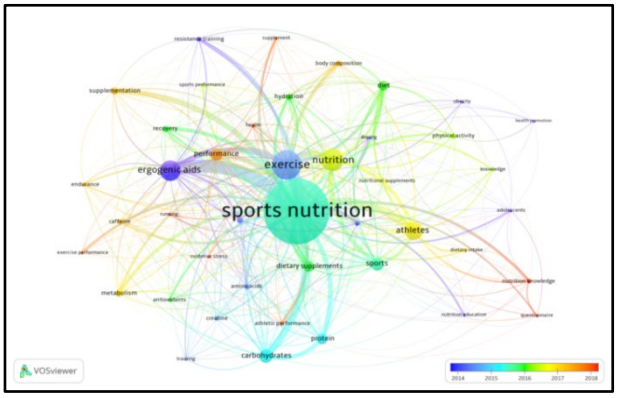

Figure 6. Overlay visualisation of the co-occurrence of authors' keywords

D. Popular Sources

A "source" is a journal, a conference proceeding, or a book. Table 2 shows the top ten sources in relation to the number of articles published between 1990 and 2021. The results were obtained using the ScientoPy default settings recommended by Ruiz-Rosero *et al.* (2017).

Table 2. The top ten active sources of sports nutrition research

Position	Source Title	Total	AGR	ADY	PDLY	h-Index
1	Nutrients	135	09.05	36.05	54.01	23
2	International Journal of Sport Nutrition and Exercise Metabolism	123	-5.0	07.05	12.02	33
3	Journal of the International Society of Sports Nutrition	109	-0.5	08.00	14.07	35
4	RBNE-Revista Brasileira de Nutricao Esportiva	108	-2.5	04.05	08.03	9
5	British Journal of Sports Medicine	53	00.05	01.00	03.08	14
6	Journal of Strength and Conditioning Research	33	02.05	04.00	24.02	16
7	International Journal of Sport Nutrition	29	00.00	00.00	00.00	14
8	Journal of Sports Sciences	26	-2.0	00.05	03.08	17
9	Sports Medicine	26	-0.5	01.00	07.07	19
10	Sports	25	-0.5	05.00	40.00	8

Note. AGR = Average growth rate; ADY = Average documents per year; PDLY = Percentage of documents in last years.

The journal with the most published articles was "Nutrients," which had 135 papers. The following journal, with 123 papers, was the International Journal of Sports Nutrition and Exercise Metabolism, and the third, with 109 documents, was the Journal of the International Society of Sports Nutrition. Also, Table 2 shows that "Nutrients," ranked first, had the highest average growth rate (AGR) from 2020 to 2021 with a value of +9.05. Consequently, the number of articles related to sports nutrition published by Nutrients has increased significantly. On the other hand, the second and third sources were both negative, indicating the annual growth rate for the last two years (2020 and 2021) had reduced.

E. Institutional and Country Analysis

The authors were identified in publications based on their particular institutions or affiliations. Knowing which institutions became the most strongly represented in sports nutrition has enabled researchers to choose research stations and build future collaborations. The bar graph in Figure 7 illustrates the top ten institutions with countries that published research on sports nutrition. Based on Figure 6, the institution with the highest number of articles was the Australian Institute of Sport (82 publications). The second position went to the University of Oxford in the United Kingdom, with 48 publications. The third-ranked was Performance Influencers Ltd, United Kingdom, with 38 publications.

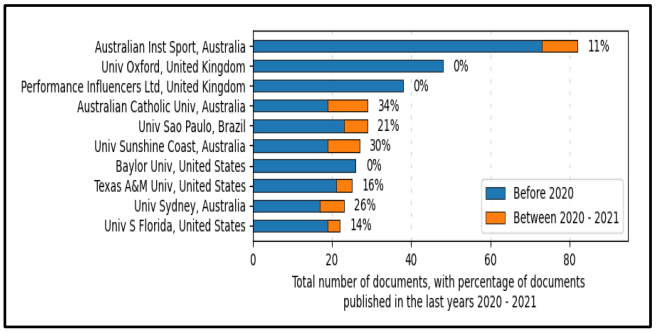

Figure 7. The top ten institutions in the country on sports nutrition research

F. Discussion

The field of sports nutrition research is advancing, as indicated by a growth in the number of articles published in the Scopus and WoS databases. It is quantified that sports nutrition research is gaining momentum due to the academic community's and practitioners' involvement, necessitating scrutiny of this field (Bassaganya-Riera *et al.*, 2021). Sports nutritionists, for instance, were enticed to evaluate publications on exercise and nutrition products (Kerksick *et al.*, 2018). This was mainly because exercise and sports play imperative roles in many people's lives. Besides, appropriate nutrition intake is vital for optimal athletic performance since it promotes biological work and moving energy (Zaman *et al.*, 2021).

It is a fact that nutrition directly impacts physical ability and endurance. The importance of nutrition for maintaining healthy body function and mobility to enable participation in exercise and sports for people of various ages and skill levels is paramount to research (Spriet, 2021). Exercise and

nutrition are inextricably linked, with numerous potential sports nutrition products, pathways, and hypotheses to test (Nieman, 2021). While some proposed sports nutrition strategies and products are novel, others are initiated on theoretical speculation (Burke *et al.*, 2019). This indirectly encourages the study of sports nutrition to facilitate current researchers who wish to delve deeper into the subject.

Based on the examination of the research area, the findings revealed that sports nutrition is dynamic, with Sport Sciences, Nutrition and Dietetics, and Food Science and Technology serving as the starting points for a better understanding of sports nutrition. This data may aid in a better understanding of publication trends in sports nutrition research. Researchers could use the evidence to choose the best gateway for their references and publish their academic works. Practitioners may use these statistics to review the previous study conducted by other researchers.

The most frequently used keywords are explicit to "Sports Nutrition," "Exercise," "Nutrition," "Athletes," and "Ergogenic Aids," which enable readers and future researchers to determine which ones to use when analysing documents. A further intriguing finding of this study was that, as shown in Figure 4, "Body composition" was the 15th topic on the list, but it had the highest PDLY (38,03%). The topic has grown the most among other keywords over the last two years (2020 and 2021). Other topics with high PDLY with more than 30% were "Nutrition," "Athletes," and "Performance." It has been noted that research on muscle, sports performance, and physical activity has recently piqued interest among scholars. Smith *et al.* (2019) discovered evidence linking muscle fitness and physical activity, particularly vigorous-intensity activities, and participation in organised sports. Inspiratory muscle training is an ergogenic resource for improving athletic performance (Karsten *et al.*, 2018). It indicates that inspiratory muscle training improves athletes' inspiratory muscle strength and sports performance.

The most cited article pertinent to "sports nutrition" was titled "*Effects of creatine supplementation on body composition, strength, and sprint performance*," published in 1998. The article was strongly related to the keyword "Exercise." The article highlighted that supplementing with creatine in addition to glucose, taurine, or electrolytes increased fat loss, bone-free mass, isotonic lifting volume, and sprint performance during rigorous resistance or agility training. This is because creatine supplementation may have an ergogenic effect. Besides, athletes use numerous supplements to improve or maintain overall health, which is recurrent with vitamin and mineral supplementation.

"Sports performance" is the third popular keyword to illustrate the content of the articles. The highest citation of an article that used this keyword was "*The acute effects of a caffeine-containing supplement on strength, muscular endurance, and anaerobic capabilities*." Published in 2006 the article explained that caffeine-containing supplements might effectively boost upper-body strength besides benefiting competitive and recreational athletes who engage in resistance training. Caffeine increases maximal strength and muscular endurance, yet, there is no evidence that caffeine habituation reduces the ergogenic effects of resistance exercise (Grgic *et al.*, 2019).

The fourth most popular keyword was "Nutrition," The most frequently cited publication on this subject was "*International society of sports nutrition position stand: nutrient timing*." The paper, published in 2017, clarified that nutrient timing includes eating whole foods, fortified foods, and dietary supplements. Following high-volume or intensive exercise, the timing of calorie intake and macronutrient ratios may increase recovery, tissue repair, muscle protein synthesis, and mood.

"Dietary supplements" was this study's fifth most popular keyword. The publication with the most citations for this keyword is "ISSN exercise & sports nutrition review update: research & recommendations," published in 2018. This review paper is intended to provide ISSN members and others interested in sports nutrition with information that may be used to evaluate the efficacy and safety of numerous standard sports nutrition products and ingredients. It is vital because a faulty or inadequate diet can significantly impact an athlete's performance. Thus, dietary supplements are an essential part of overall health and wellness. In addition, a healthier diet leads to a sturdier immune system, which reduces the chance of contracting non-communicable diseases and, as a result, extends one's lifespan (Kannan *et al.*, 2020).

The most commonly used keywords between 2014 and 2015, as per VOSviewer co-occurrence results, were "Ergogenic aids," "Carbohydrates," "Dietary supplements," "Protein," "Resistance training," and "Amino acids." These results showed that sports nutrition is critical to recovery after resistance exercise. Various post-workout feeding techniques frequently incorporate multi-ingredient mixes containing carbohydrates and protein from multiple sources (Naclerio *et al.*, 2021). Ergogenic aids could improve exercise performance capacity or training adaptations. It assists people in preparing for exercise, improving exercise efficiency, and helping people enduring hard training recover faster; however, there is also considerable debate about the ergogenic value of various nutritional supplements (Kadwe, 2020).

The cluster mapping of authors' keywords in 2015 and 2016 revealed that most articles were contributed by "Sports," "Physical activities," "Nutritional supplements," and "Antioxidants." The link between "Sports nutrition" and "Physical activities" was more important during this period. This rapport explained that research on sports nutrition and physical activities was closely related. This scenario occurred as the ratio of energy intake to energy expenditure became an essential component of athletes' diets for maintaining their health and performance (Braun *et al.*, 2019). Hence, scrutinising the association would be necessary to understand better the significance of sports nutrition in physical activities among researchers or sports nutritionists.

The current study discovered that the most frequently used keyword in 2016 and 2017 was "Sports nutrition," followed by "Athletes," "Adolescent athletes," and "Endurance exercise." The nexus between "Sports nutrition" and "Athletes" was inextricably linked. It is designated that previous researchers' studies on sports nutrition and athletes had frequently used these keywords as their primary evidence. This situation has arisen since a healthy diet is a prerequisite for achieving and maintaining peak athletic performance. Athletes have access to various foods and nutritional products to meet these requirements. Thus, sports nutritionists attend to athletes' needs before, during, and after training sessions and events (Spriet, 2019). Subsequently, studies on sports nutrition and athlete needs have expanded throughout 2016 and 2017.

The most recent keyword initiated after 2017 was "Nutrition knowledge," which is closely associated with "Sports nutrition," "Athletes," "Sports," and "Adolescent athletes." Athletes must be well-versed in this subject to understand the significance of food choices for their performance, recovery, and overall health. Zaman *et al.* (2021) found that athletes' knowledge, attitude, and practices improved due to sports nutrition education, but not their actual dietary intake, which requires more effort, focusing on protein and fat intake. Coaches must have adequate nutrition knowledge and skills because they are frequently their athletes' most critical source of nutrition knowledge (Heikkilä *et al.*, 2018). Accordingly, a brief nutrition education intervention integrated into an existing coach education course could improve nutrition knowledge (Belski *et al.*, 2018). Thus, comprehensive sports nutrition education is vital to elevate sports coaches' competency in implementing effective and holistic training for their athletes.

The Revista Brasileira de Nutrição Esportiva and the International Journal of Sports Nutrition and Exercise Metabolism published many articles, leading them to occupy the first and second positions. The Journal of the International Society of Sports Nutrition had the highest h-Index, meaning that its publications were productive and had an increased citation impact, among others. The information concerning the most popular sources will aid future researchers in identifying resources for publishing their studies based on their desired scope and determining the optimal route for publication.

The list of institutions in Figure 6 provides valuable information about sports nutrition research by academic scholars and professionals from numerous organisations. Understanding researchers' professionals is a cornerstone of sports nutrition research. Skills that boost a company's absorptive capacity are vital for executing good product innovation management related to sports nutrition. This is because designing and implementing effective dietary interventions is an essential part of the role of sports nutrition professionals (Bentley *et al.*, 2020). The number of publications in sports nutrition has increased exponentially over the last decade, but athletes' poor adherence to sports

nutrition guidelines has been frequently reported (Ali *et al.*, 2015).

This study revealed that the University of the Sunshine Coast in Australia, ranked 10th, had the highest percentage of publications in the last two years. Besides, the University of São Paulo in Brazil was the second most productive institution in the previous two years and had 35% of the articles published even though it was ranked 7th. Another proactive institution was the Texas A&M University in the United States, producing 25% of publications between 2019 and 2020. This data indicated that these three institutions were important in publishing sports nutrition research in 2019 and 2020. Furthermore, it revealed that sports nutrition research had been prioritised and was at the heart of the institutions' publications in 2019 and 2020.

The extended results of institutions with country analysis via ScientoPy also enabled us to look further at the most cited publications by the institutions. The present study identified that an article titled "Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance," published in 2016, became the most cited article. Affiliated with the Australian Catholic University, the paper emphasised the need to refer athletes to a registered dietitian nutritionist to avail them of a customised nutrition plan. The Certified Specialist in Sports Dietetics is a registered dietitian nutritionist and a credentialled sports nutrition expert in the United States and Canada.

The second most cited paper was published collaboratively by three institutions. The institutions were Baylor University, Texas A&M University, and The University of South Florida. These three institutions were based in the United States. Collaborations geared primarily at improving the body of knowledge (sports nutrition) aimed to promote athlete health and well-being. The second most cited paper was entitled "International society of sports nutrition position stand: caffeine and performance." This review paper that was published in 2010 presented ideas that caffeine-induced diuresis during exercise or any other harmful change in fluid balance would impair performance. However, the discussion expounded that any scientific literature did not support those issues.

The third most cited paper based on the list of institutions in Figure 6 was entitled "Re-Examining High-Fat Diets for Sports Performance: Did We Call the 'Nail in the Coffin' Too Soon? This review paper was published in 2015 by the Australian Institute of Sport and has obtained 119 citations. This paper concluded that an athlete could prepare for competition performance with metabolic flexibility and optimal utilisation of all muscle substrates by following current nutrition guidelines that advocate an individualised and periodised approach to fuel availability during training.

In light of the discussion contained within this study, sports nutrition researchers are most interested in "Exercise," "Sports performance," "Nutrition," "Dietary supplements," "Physical activity," "Resistance training," and "Ergogenic aids." Additionally, a growing body of research on sports nutrition focuses on "Muscle," "Physical activity," and "Nutrition knowledge." This valuable information provides readers and future researchers vis-à-vis sports nutrition publication trends, which can be elucidated by the metaphor of "*Standing on the Shoulders of Giants*." It demonstrates that the scientometric review enabled discussion of critical aspects of previous research by leveraging prior scholars' understanding to advance intellectually.

IV. CONCLUSION

This scientometric review's main goal was to examine the global evolution of sports nutrition research. The final query was scrutinised in the Scopus and WoS databases using the search string "sport* nutrition.". A search of these databases turned up 2760 papers. ScientoPy classified publications as conference papers, reviews, proceeding papers, or press articles, automatically. As a result, 399 publications were excluded from this study. After data reconciliation, this study inspected 1527 unique entries from both databases, with 1154 unique articles from the WoS and 373 unique articles from the Scopus, removing 13 duplicated articles from the WoS and 821 from the Scopus.

This study has demonstrated the remarkable growth trajectory of sports nutrition research since 2000. Sports nutrition research is gaining traction due to the involvement of academicians and practitioners, necessitating much scrutiny into this field. Exercise and sports are part and

parcel of many people's lives, and appropriate nutrition is essential for optimal athletic performance. Therefore, it indirectly entices and facilitates current and future researchers who want to delve deeper into the subject to become interested in sports nutrition.

Sport Science was the most popular subject among the top 10. The second most popular subject area was Nutrition and Dietetics, followed by Food Science and Technology in the third rank. This study found that sports nutrition had enticed publishers interested in Nutrition and Dietetics in 2019 and 2020. Therefore, future researchers need to look more and deeper into nutrition, dietetics, public health, physiology, and biochemistry better to understand sports nutrition and current developments in that area. The information provided in this facet will be valuable to researchers and enable them to identify the optimal gateway for their references and academic publications.

In previous studies, the most frequently used keywords were "Sports nutrition," "Exercise," "Sports performance," "Nutrition," and "Dietary supplements." Nonetheless, the keyword "Muscle," in the 15th topic on this list, had the highest PDLY. The topic has grown the most among other keywords over the last two years. "Sports performance" and "Physical activity" were the other topics with a high PDLY. Based on the VOSviewer analysis, the co-occurrences of author keywords that were most frequently utilized in 2014 and 2015 were "Ergogenic aids," "Carbohydrates," "Dietary supplements," "Protein," "Resistance training," and "Amino acids." With reference to the publications in 2015 and 2016, the cluster mapping of author keywords revealed that the majority of the articles were contributed by the keyword "Sports," "Physical activities," "Nutritional supplements," and "Antioxidants." In 2016 and 2017, the keyword "sports nutrition" was the most critical aspect to be discussed in the publications. The second most common keyword during this period was "Athletes," followed by "Adolescent athletes" and "Endurance exercise." The most recent keyword added after 2017 was "Nutrition knowledge."

The Revista Brasileira de Nutrição Esportiva, the International Journal of Sports Nutrition and Exercise Metabolism, and the Journal of the International Society of Sports Nutrition were the top three sources with the most published articles. The Australian Institute of Sport published the most articles, followed by the University of Oxford in the United Kingdom. Performance Influencers Ltd, based in the United Kingdom, was ranked third. Sports nutrition research has piqued the interest of academics and professionals from various organisations. Professional researchers' participation is essential and has become a cornerstone of sports nutrition research. This is because skills that increase a company's absorptive capacity are vital for executing good product innovation management in the sports nutrition industry.

The limitation of this study is primarily due to the search string that has been applied. The keyword "sport* nutrition" is employed to obtain the metadata discussed throughout the text. If additional keywords are used, the discussion may differ slightly. However, this analysis is only a starting point that can be propagated with a more in-depth investigation, such as a scoping review or a systematic literature review. The findings could develop a theoretical framework, map current state-of-the-art in the field, and quickly identify gaps in scientific research. Furthermore, the findings of this study have been projected to stimulate the development of novel ideas as a result of keyword analysis, allowing for the more effective dissemination and communication of scholarly works related to sports nutrition research and the formation of new, more relevant concepts and dimensions. It is hoped that this study will become a springboard for future work in developing sports nutrition research on topics such as sports nutrition and athletes' performances, the impact of sports nutrition on physical endurance, and also in-depth studies on the specific themes or issues discussed in this study.

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VI. CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest

VII. REFERENCES

Abd Aziz, FS, Abdullah, KH, Harith, SH & Sofyan, D 2022, 'Trends and evolution of road user behaviour research: A bibliometric review', International Journal of Information Science and Management, vol. 20, no. 3, pp. 69-93.

Abdullah, KH 2021, 'Mapping of marine safety publications using VOSviewer', ASM Science Journal, vol. 16, pp. 1-9.

Abdullah, KH, Gazali, N, Abd Aziz, FS, Syam, E, Muzawi, R, Rio, U, Cendra, R & Nazirun, N 2022, 'Six decades of publication performances and scientific maps on sports nutrition', Journal Sport Area, vo. 7, no. 1, pp. 1-22.

Alaunyte, I, Perry, JL & Aubrey, T 2015, 'Nutritional knowledge and eating habits of professional rugby league players: does knowledge translate into practice?', Journal of the International Society of Sports Nutrition, vol. 12, no. 1, pp. 1-7.

Ali, A, Al-Siyabi, MS, Waly, MI & Kilani, HA 2015, 'Assessment of nutritional knowledge, dietary habits and nutrient intake of university student athletes', Pakistan Journal of Nutrition, vol. 14, no. 5, pp. 293-299.

Aljaloud, SO & Ibrahim, SA 2013, 'Use of dietary supplements among professional athletes in Saudi Arabia', Journal of Nutrition and Metabolism, vol. 2013, pp. 1-7.

Arenas-Jal, M, Suñé-Negre, JM, Pérez-Lozano, P & García-Montoya, E 2020, 'Trends in the food and sports nutrition industry: a review', Critical Reviews in Food Science and Nutrition, vol. 60, no. 14, pp. 2405–2421.

Bassaganya-Riera, J, Berry, EM, Blaak, EE, Burlingame, B, Le Coutre, J, Van Eden, W ... & Serafini, M 2021, 'Goals in nutrition science 2020-2025', Frontiers in Nutrition, pp. 1-26.

Belski, R, Donaldson, A, Staley, K, Skiadopoulos, A, Randle, E, O'Halloran, P ... & Nicholson, M 2018, 'Brief education intervention increases nutrition knowledge and confidence of coaches of junior Australian football teams', International Journal of Sport Nutrition and Exercise Metabolism, vol. 28, no. 3, pp. 259-265.

Bentley, MR, Mitchell, N & Backhouse, SH 2020, 'Sports nutrition interventions: a systematic review of behavioural strategies used to promote dietary behaviour change in athletes', Appetite, vol. 150, pp. 1-10. Doi: 10.1016/j.appet.2020.104645.

Braun, H, Carlsohn, A, Großhauser, M, König, D, Lampen, A, Mosler, S ... & Heseker, H 2019, 'Energy needs in sports: position of the working group sports nutrition of the German Nutrition Society (DGE)', Ernährungs-Umschau, vol. 66, no. 8, pp. 146-153.

Burke, LM & King, C 2012, 'Ramadan fasting and the goals of sports nutrition around exercise', Journal of Sports Sciences, vol. 30, no. 1, pp. 37–41.

Burke, LM, Castell, LM, Casa, DJ, Close, GL, Costa, RJ, Desbrow, B ... & Stellingwerff, T 2019, 'International association of athletics federations consensus statement 2019: nutrition for athletics', International Journal of Sport Nutrition and Exercise Metabolism, vol. 29, no. 2, pp. 73-84.

Burke, LM, Hawley, JA, Jeukendrup, A, Morton, JP, Stellingwerff, T & Maughan, RJ 2018, 'Toward a common understanding of diet–exercise strategies to manipulate fuel availability for training and competition preparation in endurance sport', International Journal of Sport Nutrition and Exercise Metabolism, vol. 28, no. 5, pp. 451-463.

Chen, C & Song, M 2019, 'Visualising a field of research: a methodology of systematic scientometric reviews', PloS One, vol. 14, no. 10, pp. 1-25.

Chen, S, Bie, R, Lai, Y, Shi, H, Ung, COL & Hu, H 2019, 'Trends and development in enteral nutrition application for ventilator associated pneumonia: a scientometric research study (1996–2018)', Frontiers in Pharmacology, vol. 10, pp. 1-12.

Danh, JP, Nucci, A, Andrew Doyle, J & Feresin, RG 2021, 'Assessment of sports nutrition knowledge, dietary intake, and nutrition information source in female collegiate athletes: a descriptive feasibility study', Journal of American College Health, pp. 1-9.

Feng, C, Qu, S, Jin, Y, Tang, X, Liang, S, Chiu, AS & Xu, M 2019, 'Uncovering urban food-energy-water nexus based on physical input-output analysis: The case of the Detroit Metropolitan Area', Applied Energy, vol. 252, pp. 1-1.

Fennell, D 2004, 'Determinants of supplement usage', Preventive Medicine, vol. 39, no. 5, pp. 932-939.

Fink, HH & Mikesky, AE 2017, 'Practical applications in sports nutrition', Jones & Bartlett Learning, Burlington, Massachusetts.

Giraldo, P, Benavente, E, Manzano-Agugliaro, F & Gimenez, E 2019, 'Worldwide research trends on wheat and barley: a bibliometric comparative analysis', Agronomy, vol. 9, no. 7, pp. 1-18.

Grgic, J, Mikulic, P, Schoenfeld, BJ, Bishop, DJ & Pedisic, Z 2019, 'The influence of caffeine supplementation on resistance exercise: a review', Sports Medicine, vol. 49, no. 1, pp. 17-30.

Heikkilä, M, Valve, R, Lehtovirta, M & Fogelholm, M 2018, 'Nutrition knowledge among young Finnish endurance athletes and their coaches', International Journal of Sport Nutrition and Exercise Metabolism, vol. 28, no. 5, pp. 522-527.

Kadwe, MD 2020, 'Sports nutrition and ergogenic aids', Journal of Sports Science and Nutrition, vol. 1, no. 1, pp. 25-29.

Kannan, S, Naha, A, Singh, RR, Bansal, P, Nayak, VC, Goud, S & Rani, U 2020, 'Role of dietary supplements in sports performance', Research Journal of Pharmacy and Technology, vol. 13, no. 12, pp. 6259-6265.

Karsten, M, Ribeiro, GS, Esquivel, MS & Matte, DL 2018, 'The effects of inspiratory muscle training with linear workload devices on the sports performance and cardiopulmonary function of athletes: a systematic review and meta-analysis', Physical Therapy in Sport, vol. 34, pp. 92-104.

Kerksick, CM, Wilborn, CD, Roberts, MD, Smith-Ryan, A, Kleiner, SM, Jäger, R ... & Kreider, RB 2018. 'ISSN exercise & sports nutrition review update: research & recommendations', Journal of the International Society of Sports Nutrition, vol. 15, no. 1, pp. 1-57.

Li, L, Lu, D, Jiang, Z, Limbu, S, Qiao, F, Chen, L, Zhang, M & Du, Z 2020, 'Dietary L-carnitine improves glycogen and protein accumulation in Nile tilapia via increasing lipid-sourced energy supply: An isotope-based metabolic tracking', Aquaculture Reports, vol. 17, pp. 1-10.

Meyer, F, O'Connor, H & Shirreffs, SM 2007, 'Nutrition for the young athlete', Journal of Sports Sciences, vol. 25, no. S1, pp. 73-82.

Naclerio, F, Seijo, M, Earnest, CP, Puente-Fernández, J & Larumbe-Zabala, E 2021, 'Ingesting a post-workout vegan-protein multi-ingredient expedites recovery after resistance training in trained young males', Journal of Dietary Supplements, vol. 18, no. 6, pp. 698-713.

Nieman, DC 2021, 'Current and novel reviews in sports nutrition', Nutrients, vol. 13, no. 8, pp. 1-3.

Pabon, CDR, Sánchez-Benitez, J, Ruiz-Rosero, J & Ramirez-Gonzalez, G 2020, 'Coffee crop science metric: a review', Coffee Science, vol. 15, pp. 1-11.

Potgieter, S 2013, 'Sport nutrition: a review of the latest guidelines for exercise and sport nutrition from the American College of Sport Nutrition, the International Olympic Committee and the International Society for Sports Nutrition', South African Journal of Clinical Nutrition, vol. 26, no. 1, pp. 6-16.

Ravindra, PV, Janhavi, P, Divyashree, S & Muthukumar, SP 2020, 'Nutritional interventions for improving the endurance performance in athletes', Archives of Physiology and Biochemistry, pp. 1-8.

Rosi, A, Ferraris, C, Guglielmetti, M, Meroni, E, Charron, M, Menta, R ... & Erba, D 2020, 'Validation of a general and sports nutrition knowledge questionnaire in Italian early adolescents', Nutrients, vol. 12, no. 10, pp. 1-11.

Ruiz-Rosero, J, Ramirez-Gonzalez, G, Williams, JM, Liu, H, Khanna, R & Pisharody, G 2017, 'Internet of things: a scientometric review', Symmetry, vol. 9, no. 12, pp. 1-32.

Smith, JJ, Eather, N, Weaver, RG, Riley, N, Beets, MW & Lubans, DR 2019, 'Behavioral correlates of muscular fitness in children and adolescents: a systematic review', Sports Medicine, vol. 49, no. 6, pp. 887-904.

Sofyan, D, Abdullah, KH & Hafiar, H 2022, 'The Philosophy of Sport and Physical Education: Four Decade Publication Trends via Scientometric Evaluation', Physical Education Theory and Methodology, vol. 22, no. 3, pp. 430–442.

Spriet, LL 2019, 'Performance nutrition for athletes', Sports Medicine, vol. 49, no. 1, pp. 1-2.

Spriet, LL 2021, 'Sports nutrition for young, older, and female athletes; plant-based ingredients; and return to play during COVID-19', Sports Medicine, vol. 51, no. 1, pp. 1-2.

Su, HN & Lee, PC 2010, 'Mapping knowledge structure by keyword co-occurrence: a first look at journal papers in Technology Foresight', Scientometrics, vol. 85, no. 1, pp. 65-79.

Trakman, GL, Forsyth, A, Hoye, R & Belski, R 2018, 'Development and validation of a brief general and sports nutrition knowledge questionnaire and assessment of athletes' nutrition knowledge', Journal of the International Society of Sports Nutrition, vol. 15, no. 1, pp. 1-8.

Vitale, K & Getzin, A 2019, 'Nutrition and supplement update for the endurance athlete: Review and recommendations', Nutrients, vol. 11, no. 6, pp. 1-20.

Yeung, AWK, Mocan, A & Atanasov, AG 2018, 'Let food be thy medicine and medicine be thy food: A bibliometric analysis of the most cited papers focusing on nutraceuticals and functional foods', Food Chemistry, vol. 269, pp. 455-465. Doi: 10.1016/j.foodchem.2018.06.139

Zaman, NNZK, Muhamad, AS & Jusoh, MRC 2021, 'Knowledge, attitude, practice (KAP) and dietary intake of young university athletes following sports nutrition education', Malaysian Journal of Nutrition, vol. 27, no. 2, pp. 189-200.

Zhong, B, Wu, H, Li, H, Sepasgozar, S, Luo, H & He, L 2019, 'A scientometric analysis and critical review of construction related ontology research', Automation in Construction, vol. 101, pp. 17-31.