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Reviews. Scientific output of neuroscience in sport sciences between 2010-2024: analysis of decision making, cognitive factors and sport performance with VOSviewer
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# Scientific output of neuroscience in sport sciences between 2010-2024: analysis of decision making, cognitive factors and sport performance with VOSviewer

# Producción científica de la neurociencia en las ciencias del deporte entre 2010-2024: análisis de la toma de decisiones, factores cognitivos y rendimiento deportivo con VOSviewer

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**Abstract**
Sports performance has been studied from the influence of fatigue in cognitive processes and decision-making, based on the integration of the contributions of neurophysiology and neuroimaging, which have allowed the implementation of alternative methods that measure the load generated on the central nervous system The objective was to analyze the trend and evolution of the scientific production of decision-making and cognitive factors to establish the relationship between neuroscience and sports performance, based on a bibliometric review in the Web of Science, Scopus and PubMed databases, including documents published between January 2010 and April. 2024. A review was carried out based on PRISMA recommendations, and a definitive sample of 409 documents was obtained. The results reflect that the greatest production occurs in research articles (82.15%) and review articles (15.15%). For the publication period, it is established that between 2019 and 2023 there was a considerable increase (41.21%). Between 2016 and 2020 there is a significantly higher number of citations than the average (n= 510). It is determined that Fortes, LS., and Russell, S., are the authors with the largest number of studies. The areas of knowledge that have dealt with the study of sports performance are Sport Sciences, Psychology, and Neuroscience. Compared to the journals that produce the most knowledge, they were located in Q1-Q2. The countries that produce the most knowledge are the United States, England, Australia, and Germany. The keywords most used in the studies are Performance", "Sport", "Decision Making", "Expertise" and "Cognition. Neuroscience in sport has been established mainly as an interdisciplinary scientific discipline focused on the improvement of cognitive processes associated with attention, memory, mental fatigue, cognitive performance, cognitive functions and sleep. All these variables are indispensable to manifest a high sports performance.

**Keywords:** fatigue; sports sciences; sport performance; decision making; cognition.

**Resumen**
El rendimiento deportivo ha sido estudiado a partir de la influencia de la fatiga en los procesos cognitivos y en la toma de decisiones, basándose en la integración de los aportes de la neurofisiología y la neuroimagen, que han permitido la implementación de métodos alternativos que miden la carga generada sobre el sistema nervioso central. El objetivo fue analizar la tendencia y evolución de la producción científica de la toma de decisiones y factores cognitivos para establecer la relación entre la neurociencia y rendimiento deportivo, a partir de una revisión bibliométrica en las bases de datos Web of Science, Scopus y PubMed, incluyendo los documentos publicados entre enero de 2010 y Abril. 2024. Se realizó una revisión basada en las recomendaciones PRISMA y se obtuvo una muestra definitiva de 409 documentos. Los resultados reflejan que la mayor producción se produce en artículos de investigación (82,15%) y artículos de revisión (15,15%). Para el periodo de publicación, se establece que entre 2019 y 2023 se produce un aumento considerable (41,21%). Entre 2016 y 2020 hay un número de citas significativamente superior a la media (n= 510). Se determina que Fortes, LS., y Russell, S., son los autores con mayor número de estudios. Las áreas de conocimiento que se han ocupado del estudio del rendimiento deportivo son Ciencias del Deporte, Psicología y Neurociencia. En cuanto a las revistas que producen más conocimiento, se localizan en Q1-Q2. Los países que producen más conocimientos son Estados Unidos, Inglaterra, Australia y Alemania. Las palabras con mayor ocurrencia en los estudios son «Rendimiento», «Deporte»,

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«Toma de decisiones», «Experiencia» y «Cognición». La neurociencia en el deporte se ha establecido principalmente como una disciplina científica interdisciplinaria enfocada en la mejora de los procesos cognitivos asociados a la atención, la memoria, la fatiga mental, el rendimiento cognitivo, las funciones cognitivas y el sueño. Todas estas variables son indispensables para manifestar un alto rendimiento deportivo.

**Palabras clave:** fatiga; ciencias del deporte; rendimiento deportivo; toma de decisiones; cognición.

## Introduction

In The peak performance achieved as referred to by the traditional Olympic motto "Citius, Altius, Fortius" ("Faster, Higher, Stronger") has led research to find ways through the advancements in Sports Science to evaluate and develop human potential (Faigenbaum et al., 2016). This is possible by the interrelation of physical, affective, and cognitive processes that favor performance (Piggott et al., 2020). In this sense, various studies have focused on considering psychological or cognitive load factors and their association with sports performance (Habay et al., 2021; Mellalieu et al., 2021). Sports performance has been studied in response to brain processes and, specifically, cognitive-motor behavior expressed in neural, psychomotor efficiency, and cognitive inference, among others, which are mediated by brain activity (Gomez-Pinilla & Hillman, 2013; Schmidt-Kassow & Kaiser, 2023). Neuroscience originated to promote knowledge of brain functions in response to human behavior, so it was incorporated into disciplines preceding the global study of the Nervous System (NS) (Tamorri, 2004). Thus, it aims to understand the communication and processing of NS information (Seguin et al., 2023). However, the historical context of human bipedalism has permeated motor function and cognition (Schulkin, 2016). These components should not be studied in isolation, since oscillations in neural activity can represent motor and cognitive processes with similar evolutionary roots (Leisman et al., 2016). In this sense, basic neuroscience research has been providing information related to how athletes' brains work, and the differences that exist with non-athletes (Nakata et al., 2010; Li & Smith, 2021). Studies have identified that the success of high-performance athletes is determined by mental factors (Benítez-Sillero et al., 2021), especially, by psychoneuronal or physiological aspects of the NS that increase neural activity. These are manifested in the ease of learning, and adaptation to motor gestures or specific sports situations (Bradley et al., 2020). Similarly, it has been found that forms of cognitive processing such as attention, perception, and memory

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(Colom et al., 2010) are associated with motor processing, sensorimotor, and motor planning that influence psychomotor performance (Leisman et al., 2016).

The understanding of sensory, motor, and cognitive processes integrates to favor imagination and creativity in sports actions (Voigt & Raab, 2024). Meanwhile, the necessary resources to focus attention have led to the incorporation of portable and laboratory neuroscience devices, among which electroencephalography (EEG), functional Near-Infrared Spectroscopy (fNIRS), functional Magnetic Resonance Imaging (fMRI), Magnetic Sesonance Spectroscopy (MRS), functional-magnetoencephalography imaging, and transcranial magnetic stimulation stand out (Narayana et al., 2019), which allow characterizing specific aspects of sports activity and neurofunctional activity developed (Crivelli & Balconi, 2017; Balconi & Crivelli, 2019; Balconi et al., 2019; Balconi et al., 2019b). Likewise, it is necessary to highlight that there are difficulties associated with the use of technology in the evaluation of brain processes associated with the preparation of athletes, sensor location, control of the environment in which the evaluation takes place, signal processing, sensitivity of the instrument used, portable or laboratory recording of the signal, and the quality of the physiological data captured (Perrey, 2008; Thompson et al., 2008; Park et al., 2015; Cheron et al., 2016). Recently, Crivelli and Balconi (2022) highlighted that neuro-evaluation in sports proposes an integrative approach to determine athletes' performance, pointing out that a multifactorial reference model is necessary to evaluate performance through the interrelation of the constructs of Physical Fitness-PhyF (Jeffreys & Moody, 2016), Psychological Fitness-PsyF (Heaps, 1978), and Neurocognitive Fitness-NCF (Aidman, 2020). Although the Sports Sciences have been contributing knowledge from various areas to determine athletes' performance, few theoretical-practical contributions associate brain processes (Loland et al., 2023) in training and competition processes, so discussions focus on investigating the communication of complex brain networks (Seguin et al., 2023), as well as neural and psychomotor efficiency (Bradley et al., 2020).

Therefore, experts have focused their attention on the efficient development of neural networks, understanding that such neural activity decreases during task processing, suggesting that table tennis athletes who train over the long term possess a task-focused organization (Guo et al., 2017). For this reason, sports studies have associated neural

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efficiency with tasks that involve motor functions in karate athletes after measuring cognitive dynamics during rest and increased mental load (Duru & Assem, 2018). The various studies from neuroscience have allowed the study of sports performance from the modulation of inhibitory control, determining that athletes show shorter stop signal reaction times than those who are not, and this is the result of systematic practices in cognitively demanding environments, and, in turn, aerobic and anaerobic fitness do not constitute predictors of performance in terms of response suppression in highly competitive athletes (Albaladejo-García et al., 2023). The expertise of the athlete through cognition and sports proficiency has been recently studied, determining that there are universal and task-specific cognitive processes, among which the influence of mental images stands out (Morán et al., 2019), which allow perceptual information to be represented in the absence of sensory information (Munzert et al., 2009). Fatigue in sports competition is closely related to the physical and cognitive demands experienced by athletes because performance corresponds to cognitive skills among which attention, working memory, and decision-making stand out (Dambroz et al., 2022). Therefore, the study of the characteristics of athletes' brains from the contributions of neurophysiology and neuroimaging has allowed the implementation of alternative methods aimed at measuring the load generated on the Central Nervous System (CNS) from direct current potentials (Tan et al., 2019). Similarly, other studies have focused on recognizing decision-making in athletes from the tracking of multiple three-dimensional (3D) objects (Romeas et al., 2016), sports vision, and digital training techniques, determining that 3D tracking training generates significant improvements in the quality of decisions made (Harenberg et al., 2022).

On the other hand, Motor Imagery (MI) has been studied from the interrelation between cognitive neuroscience and sports psychology (Moran & O'Shea, 2020), determining that it is a constantly adapting mental state that allows a motor movement to be represented by working memory without a motor output (Decety, 1996). Therefore, cognitive functioning in sports is given by the integration of observation and anticipation processes (Scharfen & Memmert, 2019). For this, its evaluation has been developed using neuroimaging techniques, perceptual-cognitive skills, and transfer to specific sports performance, as well as executive functioning and association with cognitive

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performance in sports (Broadbent et al., 2015; Hernández-Mendo et al., 2019). As far as is known, this is one of the first bibliometric studies that focuses on analyzing the trend of scientific production related to neuroscience and sports performance. Therefore, bibliometric analyses have allowed the exploration of the scientific production of different countries, institutional affiliations, researchers, journals, keywords, and citations to understand how a particular topic has been studied (Chen et al., 2023; Becerra Patiño et al., 2024a), and, with this, project future lines of research.

Therefore, the findings of the present bibliometric study may be useful for coaches and researchers who develop studies related to neuroscience, cognitive processes, fatigue, and decision-making, among others, so that they can establish relationships with other collaborators and researchers, as well as journals to consult the generation of new knowledge on the subject. Therefore, this study aimed to analyze the trend and evolution of scientific production of Neuroscience and Sports Performance, based on the use of bibliometric review using Web of Science (WoS), Scopus, and PubMed databases, including documents published between 2010 and April 2024. Give a clear statement of the purpose of the paper and provide relevant context to support the basis for the paper and the significance of the work.

## 2. Materials & method

### *2.1. Study Design*

The present bibliometric study is based on an analysis of the scientific production in the field of neuroscience in sports over the past 15 years (2010-2024) using bibliometrics as a research technique in the databases of WoS, Scopus, and PubMed (Khatra et al., 2021; Park & Jeon, 2023; Becerra Patiño et al., 2024b; Martínez-Benítez et al., 2024). Therefore, due to its theoretical origin and basis on previous studies, the present study is recognized as a Theoretical and retrospective study (Ato et al., 2013).

### *2.2. Eligibility Criteria*

The inclusion criteria for studies were: (i) original scientific studies; ii) full access to the document to complement the first review; iii) publication date between January 1, 2010, and April 15, 2024; iv) studies without language restriction; v) scientific articles, reviews, books, review chapters, letters to the editor, conferences, etc. Works that did not meet any of the above inclusion criteria were eliminated. To classify the documents, a matrix

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analysis was developed in Microsoft Excel (2006 version: Microsoft Corporation, Redmond, WA, USA) based on the following categories: 1) type of document; 2) year of publication; 3) name of the authors; 4) number of authors per study; 5) area of knowledge; 6) name of the journal; 7) country of the journal; 8) the number of publications; 9) Journal Citation Reports (JCR) Quartile; 10) Journal Citation Indicator (JCI) Quartile; 11) average number of citations per published article; 12) documents by institutional affiliation; 13) several documents by affiliation with department; 14) documents by publisher; 15) number of documents by language.

*2.3. Search Strategies*

The search was conducted between April 15 and April 28, 2024. A review based on the PRISMA recommendations (Page et al., 2022) was carried out using WoS, Scopus, and PubMed databases. The following search phrase was used: ("neuroscience" [Title/Abstract]) OR ("athlete" [Title/Abstract]) AND ("sport performance" [Title/Abstract]) OR ("competitive level" [Title/Abstract]) AND ("decision making" [Title/Abstract]) OR ("cognitive" [Title/Abstract]). The Boolean operators used were [AND] and [OR]. Additionally, filters were applied to the descriptors related to the year of publication between 2010 and up to April 15th, 2024, open access documents, and document types (Letter, Editorial, Book Chapter, Review, Article). A step-by-step process was developed for document selection based on bibliometric criteria (Salinas-Ríos & García-López, 2022; Mamani-Jilaja, 2023; Becerra Patiño et al., 2024c). Initially, 11.108 documents were collected and subjected to a metadata regulation process to eliminate duplicates or documents without full access. After the PRISMA procedure, only 409 documents met the eligibility criteria established for the present study (Figure 1).

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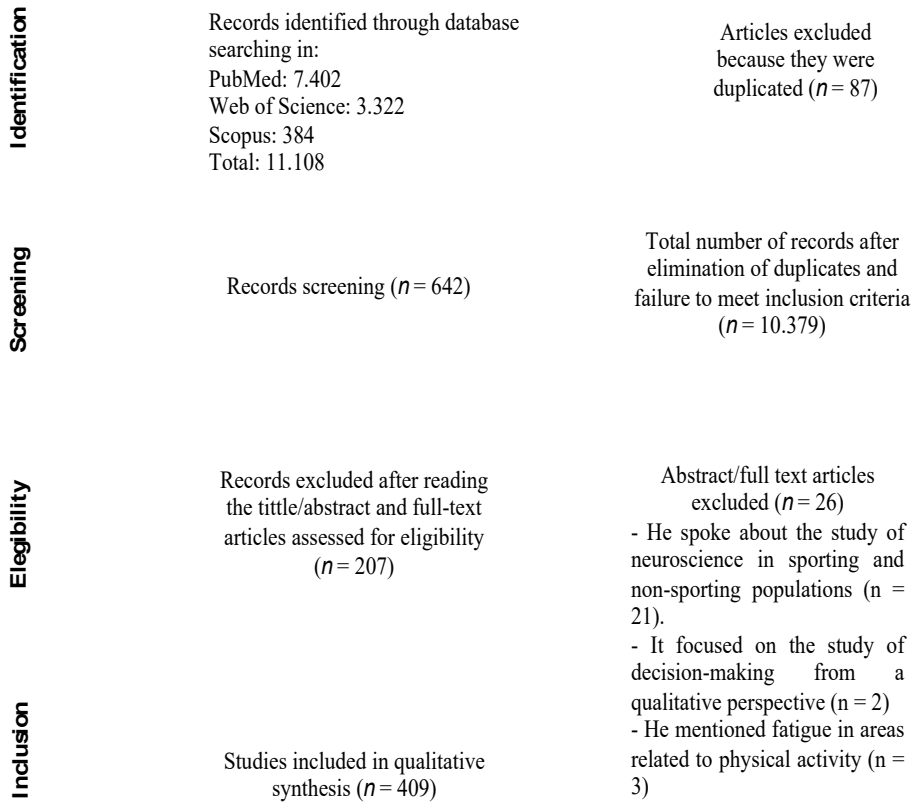
**Figure 1**. Flow diagram for selection of studies according to PRISMA guidelines




### *2.4. Data Analysis*

To analyze the bibliometric information, laws have been used to determine academic and research productivity by authors, among which H-Index (Hirsch, 2005) and Lotka's Law (Bufrem & Prates, 2005) stand out. Based on this, it can be determined that a certain number of h documents have been cited at least a minimum number of h times (Crespo & Simoes, 2019). Another important law that allows for the establishment of the systematic increase of a sample obtained about a certain number of extracted publications (Price's Law), is carried out from the $R^2$ coefficient (Price, 1976). Finally, Zipf's Law was applied to establish the most important connections between the different keywords used by authors (Vega-Muñoz et al., 2022). The analysis of the documents was carried out from the download of metadata in two formats: i) plain text for the creation of co-citation and co-occurrence maps and ii) Excel format for subsequent analysis of bibliometric criteria. For the co-citation node maps for authors, journals, organizations, and referenced citations, the VOSViewer software (v.6.19, Center for Science and Technology Studies,

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Netherlands) was used, which allows for the creation of two-dimensional graphs (Van Eck & Waltman, 2014; 2020). The main purpose of these graphs is to determine the exponential increase in scientific production in a certain area and consider the availability of information found in the databases consulted (McAllister et al., 2022; Viswalekshmi et al., 2023). On the other hand, for statistical analysis, a Microsoft Excel spreadsheet (v. 2006, Microsoft Corporation, Redmond, WA, USA) was used to generate tables and figures (frequency/percentage). Ultimately, for the analysis of information using VOSviewer, a fragmentation analysis with an attraction force of 3 and a repulsion force of 2 was employed.

## 3. Results

### *3.1. Type of document*

Regarding the type of document, Table 1 shows that the lowest number of documents is related to the categories of letters, editorials, and book chapters (Gamonales et al., 2018). Review studies have been written in large percentages, and it's the scientific dissemination articles that have the greatest development.

**Table 1.** Documents by type.

| Type | Number of publication | Percentage % |
|---|---|---|
| Letter | 1 | 0.24% |
| Editorial | 3 | 0.73% |
| Book Chapter | 7 | 1.71% |
| Review | 62 | 15.15% |
| Article | 336 | 82.15% |
| Total | 409 | 100% |

### *3.2. Citation Analysis*

About the bibliometric analysis conducted, Figure 2 reveals the behavior of scientific production on neuroscience and sports performance during the publication period between 2010 and 2024. Thus, it can be observed that the number of publications remained low from the year of the first referenced study in 2010 until 2015 (13.69%), and from 2016 onwards, there is growth, except for 2021 with a total of 40 studies (9.77%). Then, between 2022 and 2023, there was a considerable increase (32.02%), with 2023 being the year of greatest production (16.62%). Additionally, the figure shows the increase in the number of documents per year and the corresponding number of citations.

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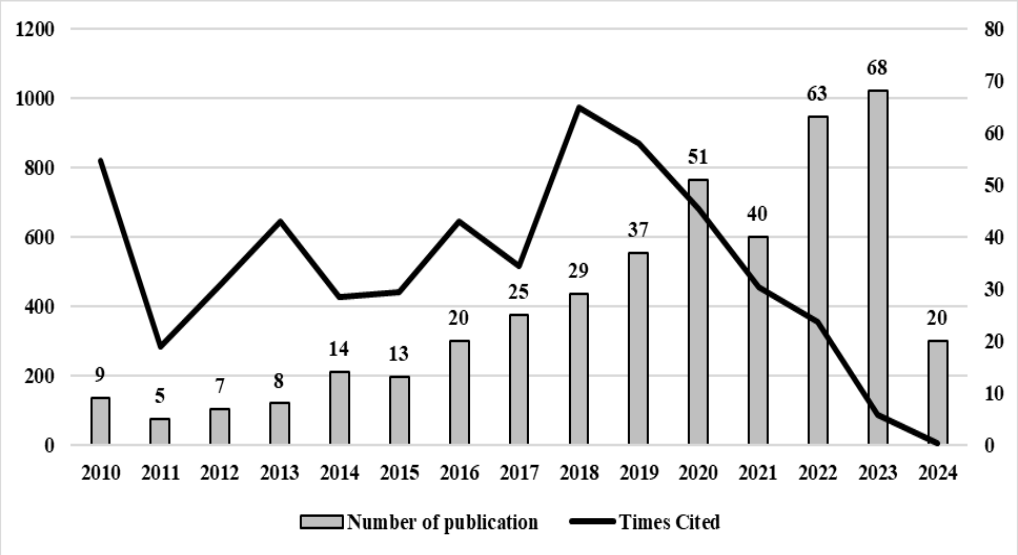
It details how the years 2010 (820 citations), 2013 (644 citations), 2016 (645 citations), 2017 (515 citations), 2018 (973 citations), 2019 (869 citations), and 2020 (681 citations) show a significantly higher number of citations than the average ($n$ = 510.86). Likewise, it is evident that between 2011 and 2012, as well as 2014, and between 2021-2024, the number of citations remains below the average.

**Figure 2.** Evolution of the number of annual publications and citations.




In Table 2, the 10 documents with the highest number of citations since their publication are shown, as well as the average number of citations. Similarly, it is observed that more than half of the referenced documents are between 2010 and 2015, except for one document from 2016. It is worth mentioning that the most cited studies were published between 2010-2016.

### *3.3. Authors' analysis*

Regarding the number of documents per author considering the first author, Table 3 compiles the authors of the largest number of documents. It is determined that Fortes, L.S., and Russell, S., are the authors with more studies. Thus, the first 12 authors with a minimum of three published studies have participated in 10.75% of the total scientific production.

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**Table 3.** Number of documents per author considering the first author.

| Author | Number of publications | % |
|---|---|---|
| Fortes, LS | 6 | 1.46 |
| Russell, S | 6 | 1.46 |
| Furley, P | 4 | 0.97 |
| Wang, CH | 4 | 0.97 |
| Staiano, W | 3 | 0.73 |
| Sun, H | 3 | 0.73 |
| Van Biesen, D | 3 | 0.73 |
| Lucia, S | 3 | 0.73 |
| Konings, MJ | 3 | 0.73 |
| Heilmann, F | 3 | 0.73 |
| Ehmann, P | 3 | 0.73 |
| Beavan, A | 3 | 0.73 |
| Total | 44/409 | 10.75/100% |

On the other hand, academic cooperation can be considered based on the number of authors. It is established that the largest number of studies is carried out between 1 to 6 authors with more than a third of the total scientific production (81.86%). The lowest production is found for ≥ 9 authors (Table 4).

**Table 4.** Total number of documents by number of authors´s.

| Number of author´s | Number of publications | Percentage % |
|---|---|---|
| 1 a 2 | 82 | 20.04 |
| 3 a 4 | 163 | 39.85 |
| 5 a 6 | 90 | 22.00 |
| 7 a 8 | 44 | 10.75 |
| ≥9 | 30 | 7.33 |
| Total | 409 | 100% |

Figure 3 shows the interactions produced between the authors. The size of the nodes represents the number of published documents, and the color corresponds to the publication period. It is observed how the node integrated by de Memmert, D., was strong in 2016, the node of Raab, M., was strong in 2018, while the node of Spielmann, J., was one of the strongest in 2022. On that same path, there is a node that references several authors about the year 2022, highlighting Beavan, A., Mayer, J., and Ehmann, P. For the co-authorship map, it was established that the minimum number of authors would be three. documents and 10 citations, thus, the largest set of connected elements was made up of 27 authors.

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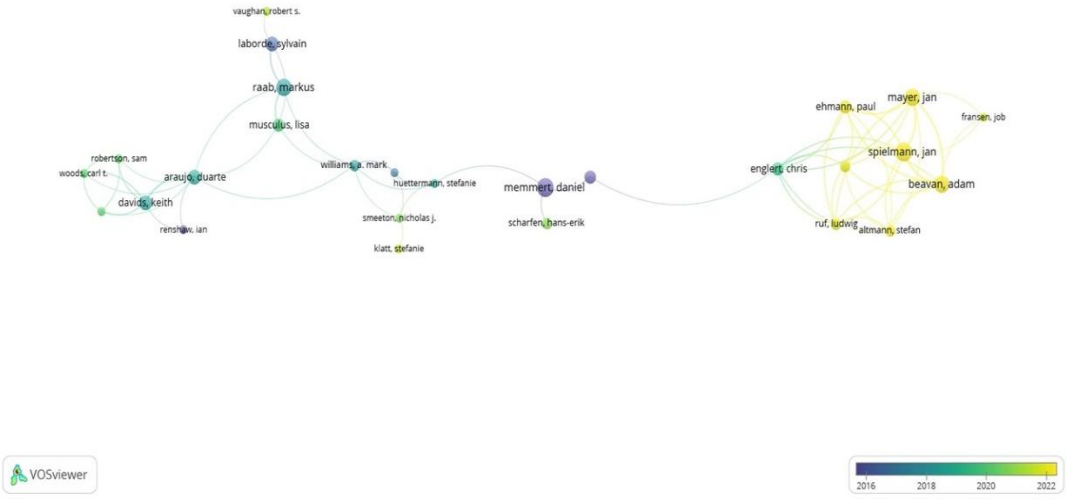
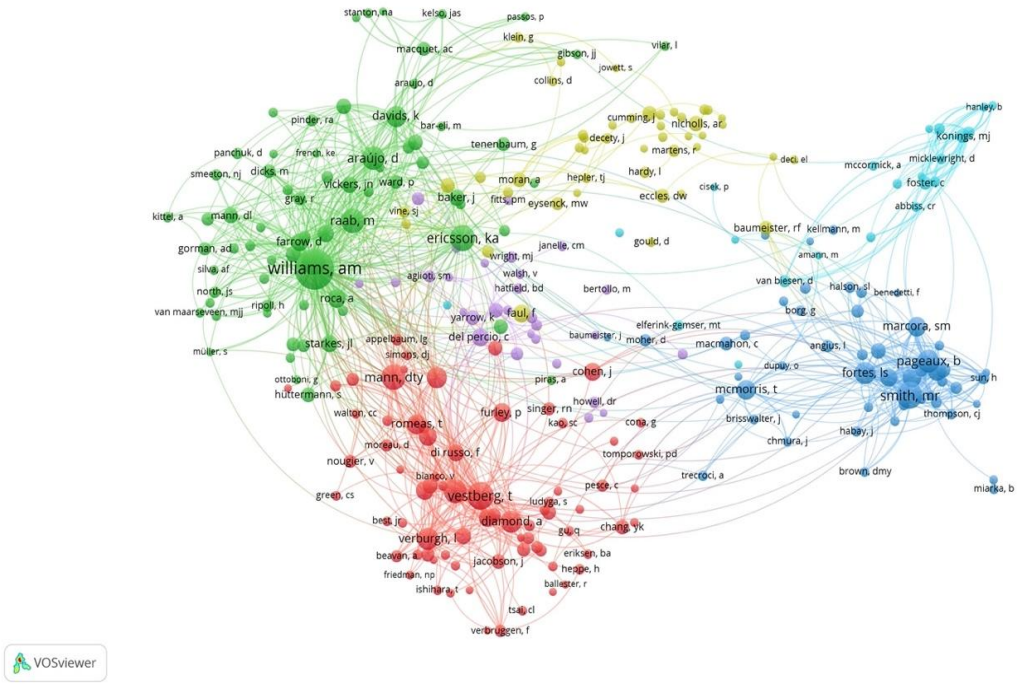
**Figure 3.** Co-authorship map.




Regarding the co-citation map for author citations, it was established that there are 10,512 authors, so a minimum number of 10 citations per author was considered, reaching 295 authors who met the threshold. There, the strong nodes led by Williams, A.M. (213 citations), Vestberg, T. (102 citations) and Smith, M.R. (92 citations) (Figure 4).

**Figure 4.** Co-citation map for the cited authors.



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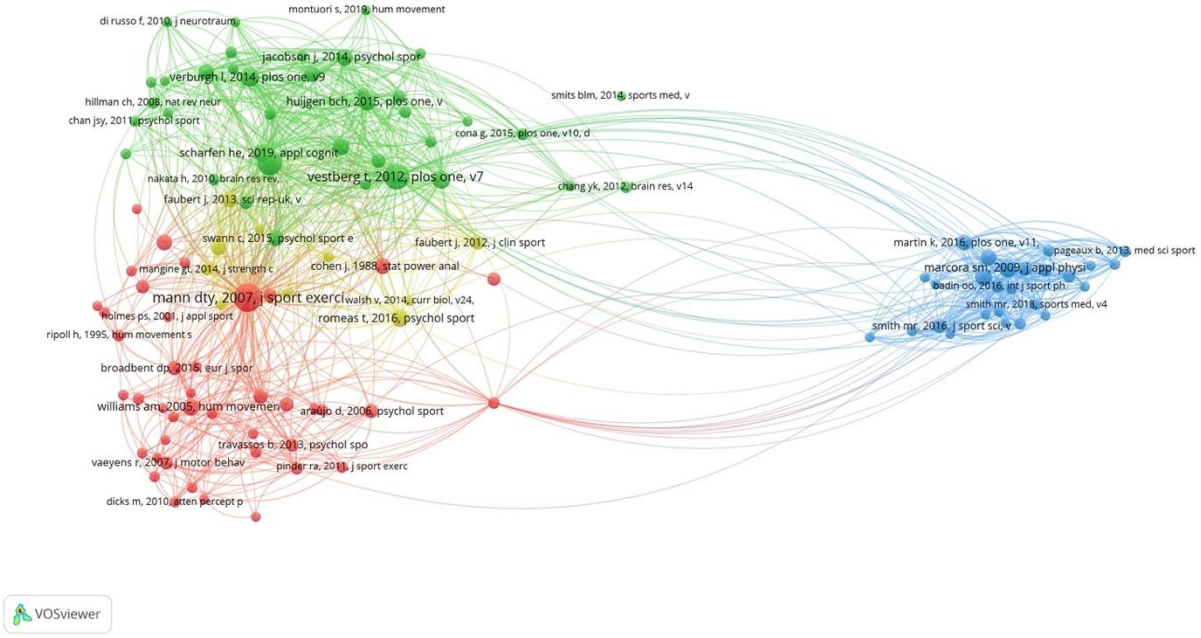
Regarding the co-citation map for reference citations, it was established that there are 15,370 cited references, so a minimum number of 10 citations per referenced citation was considered, reaching 116 that met the threshold. There, they detail that the strong nodes are led by the studies of Mann, D. (2007), Vestberg, T. (2012), and Scharfen, H.E. (2019) (Figure 5).

**Figure 5.** Co-citation map for cited references.




### *3.4. Keyword analysis*

Considering the keywords established for the studies in response to time, the following figure details how for the years 2018 and 2019 the most referenced terms are “Decision making”, “Attention”, “Anxiety” and “Expertise”, while, between 2019 and 2020, the main concepts are related to “Brain”, “Skill”, “Soccer” and “Performance”. Between the years 2020 and 2021, the most referenced terms are: “Cognition”, “Athletes”, “Team Sports” and “Cognitive performance”. Finally, for the years 2021-2022 the terms that stand out the most are “Sports performance”, “Mental Fatigue” and “Exercise” (Figure 6).

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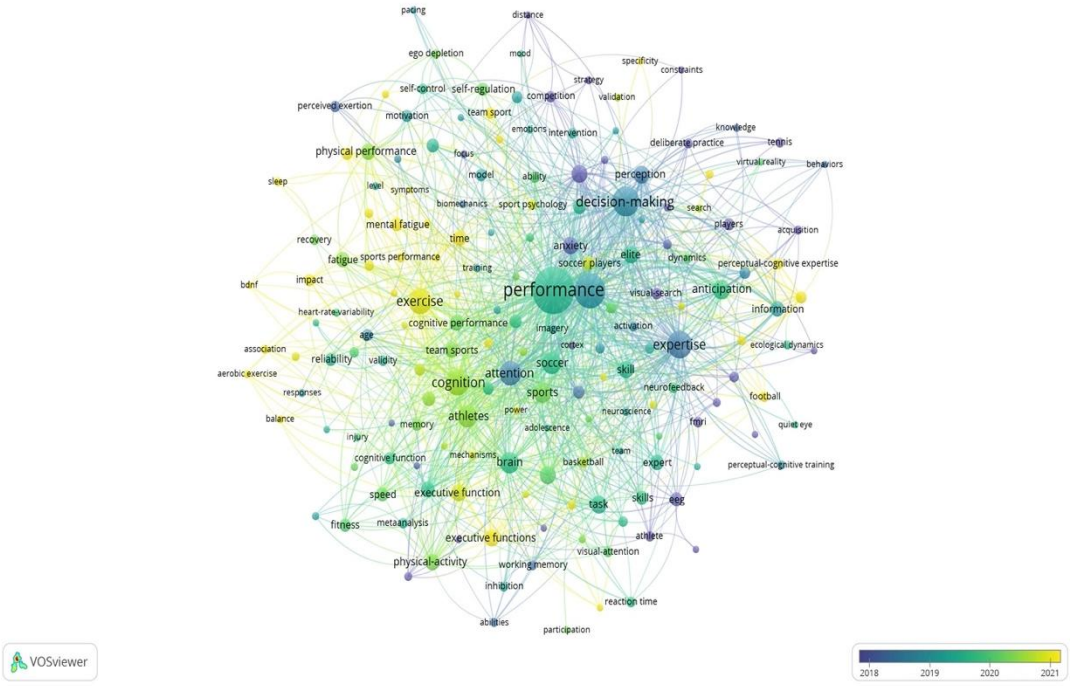
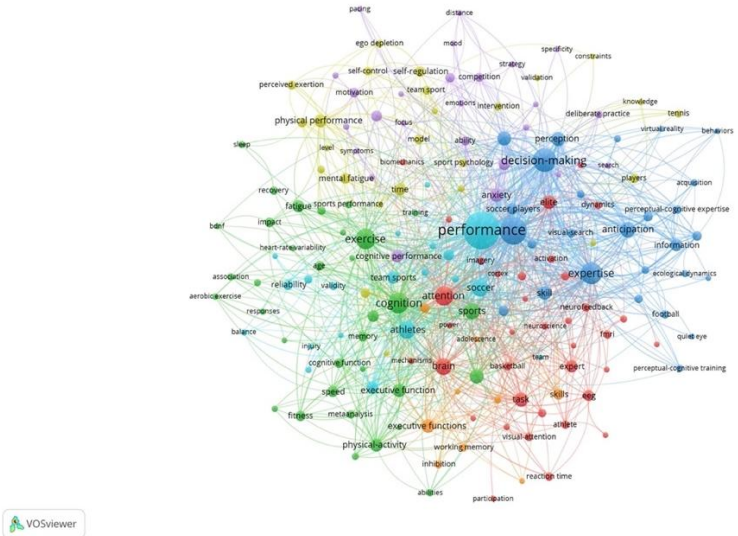
**Figure 6.** Co-occurrence map of the most used keywords as a function of time.




Considering the keywords established for the studies, 1934 terms were identified. 176 terms have a minimum occurrence of 5. The most used keywords are: “Performance” (*n* = 175), “Sport” (*n* = 100), “Decision Making” (*n* = 74), “Expertise” (*n* = 62) and “Cognition” (*n* = 53) (Figure 7).

**Figure 7.** Co-occurrence map of the most used keywords.



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### *3.5. Analysis of the journals*

To establish the relationship between the name of the published journals with scientific knowledge, the country, its quartile, the JCI index for the year 2022, the number of citations per journal, and the average number of citations Table 5 was prepared per published article. This table compiles the information corresponding to 144 documents of the 409 eligible ones (35.20%). The first nine journals that produce scientific knowledge of neuroscience in sports performance correspond only to 4 countries, Switzerland (15.89%), the Netherlands (8.06%), the United Kingdom (6.35%), and the United States (4.88%), the ones with the greatest production they generate. The nine journals with the most significant number of published documents belong to the European and North American continents. There is no corresponding magazine to South America, Asia, Africa, and Oceania. Compared to the quartiles of the journals where knowledge is produced, these are published only in Q1 and Q2 journals, and in turn, Q1 journals are the ones that receive the greatest number of citations when compared to Q2.

Of the first nine journals with the largest number of published documents, there are mainly journals related to Psychology. It is worth noting that the two journals with the highest production are “Frontiers in Psychology” and “Psychology of Sport and Exercise” with 41 documents and 19.29 citations, and 33 documents and 26.27 citations on average per published article respectively.

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**Table 5. Name of the journal, country of the journal, number of publications, Category Rank, JCR Category, Quartile, JCI 2022, total citations and average number of citations per published article.**

| Journal | Country Journal | Num Pub | Cat Rank | JCR Category | Cat Q | JCI 2022 | T Num Cit | Av n cit pub art |
|---|---|---|---|---|---|---|---|---|
| **Frontiers in Psychology** | Switzerland | 41 | 52/ 215 | Psychology, multidisciplinary | Q1 | 1.04 | 789 | 19.29 |
| **Psychology of Sport and Exercise** | Netherlands | 33 | 21/ 121 | Sport Sciences | Q1 | 1.21 | 867 | 26.27 |
| **European Journal of Sport Science** | United Kingdom | 13 | 26/ 121 | Sport Sciences | Q1 | 1.14 | 451 | 34.69 |
| **Journal of Sport Sciences** | United Kingdom | 13 | 28/ 121 | Sport Sciences | Q1 | 1.12 | 254 | 19.53 |
| **Int. J. Sports Physiol. Perform** | United States | 11 | 17/ 121 | Sport Sciences | Q1 | 1.27 | 260 | 23.63 |
| **IJSEP** | United States | 9 | 46/ 115 | Psychology, Applied | Q2 | 0.86 | 61 | 6.77 |
| **International Journal of Environmental Research and Public Health** | Switzerland | 8 | 110/ 392 | Public, Environmental & Occupational Health | Q2 | 0.93 | 47 | 5.87 |
| **Frontiers in Sport and Active Living** | Switzerland | 8 | 45/ 121 | Sport Sciences | Q2 | 0.86 | 34 | 4.25 |
| **Frontiers in Human Neuroscience** | Switzerland | 8 | 39/92 | Psychology | Q2 | 0.73 | 46 | 5.75 |
| **Total: 9 Journals** | 4 Countries | 144/ 409 | | 4 categories | | **Q1** 5 **Q2** 4 **Q3** 0 **Q4** 0 | 2.809 | |

**Note. Num Pub: Number of publications; Cat Rank: Category Rank; JCR: Journal Citation Report; Cat Q: Category Quartile; JCI: The Journal Citation Indicator is a measure of the average Category Normalized Citation Impact (CNCI) of citable items (articles and reviews) published by a journal over a recent three-year period. It is used to help you evaluate journals based on other metrics besides the Journal Impact Factor (JIF); T Num Cit: Total number of citations; Av n cit pub art: Average number of citations per published article; Int. J. Sports Physiol. Perform: International Journal of Sports Physiology and Performance; IJSEP: International Journal of Sport and Exercise Psychology**

Considering the total citations received by each journal (*n*=4467), it was established that the co-citation map for the journal citations was at least 5; only 535 complied. It is revealed that the main journals are: "The Journal of Sport Sciences" (736 citations), "Psychology of Sport and Exercise" (633 citations), "Plos One" (562 citations), "Journal of Sport and Exercise Psychology" (540 citations), and "Frontiers in Psychology" (506 citations) (Figure 8).

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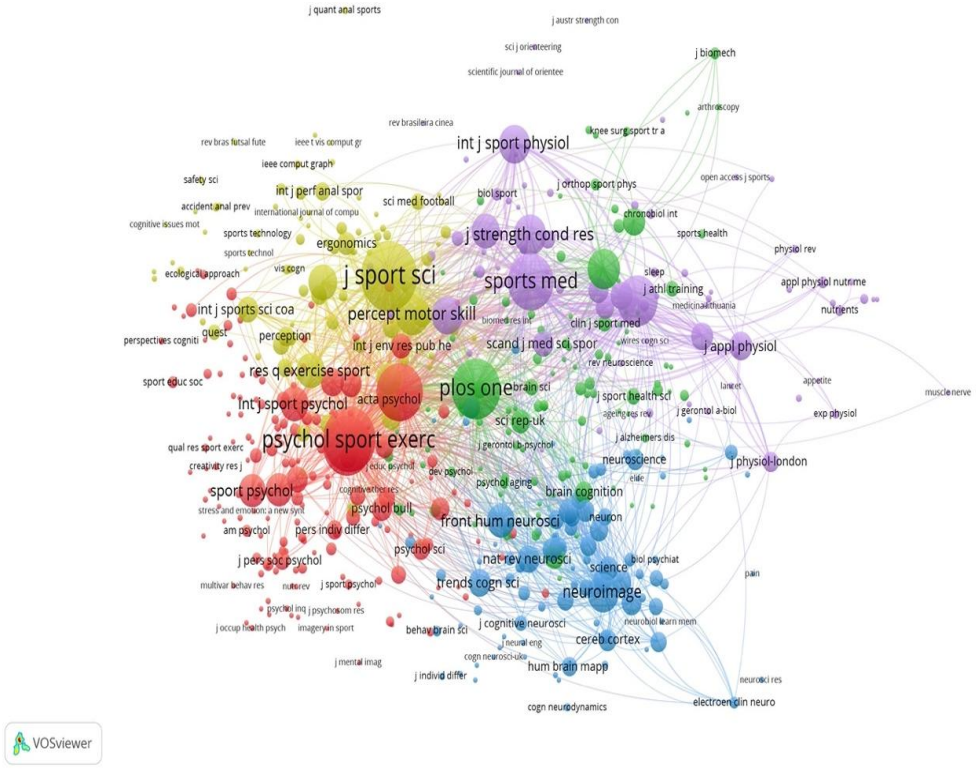
**Figure 8.** Co-citation map for journal citations.




### *3.6. Editorial Analysis*

Another important fact about scientific production is publishers that publish scientific knowledge since some are open-access (Table 6). The 9 main publishers generate 75.55% of the total scientific production. “Taylor & Francis”, “Frontiers”, “Elsevier” and “MDPI” are more than half of the total production (54.27%). Likewise, it is worth noting that the one with the highest number of citations per number of documents is “Wiley” with an average of 79.1 citations per published article.

**Table 6.** Total number of documents by publisher.

| Name | Number of documents | Number of citation |
|---|---|---|
| Taylor & Francis | 67 | 1264 |
| Frontiers | 64 | 957 |
| Elsevier | 63 | 1713 |
| MDPI | 28 | 205 |
| Springer | 27 | 237 |
| Human Kinetics Publ Inc | 25 | 475 |
| SAGE | 15 | 131 |
| Wiley | 10 | 791 |
| Lippincott Williams & Wilkins | 10 | 161 |
| Total: 9 publisher | 309/409 | 5934 |

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### *3.7. Knowledge areas*

Compared to the areas of knowledge that have been covered by publications related to neuroscience and sports performance, it is found that "Sport Sciences", "Psychology" and "Neuroscience" have more than a third (84.33%) of the published documents (Table 7).

**Table 7.** Knowledge areas.

| Area* | Number of publications | % |
|---|---|---|
| Sport Sciences | 186 | 45.47 |
| Psychology | 97 | 23.71 |
| Neuroscience | 62 | 15.15 |
| Multidisciplinary Sciences | 17 | 4.15 |
| Physiology | 15 | 3.66 |
| Rehabilitation | 9 | 2.20 |
| 7 areas | 386/409 | 94.37/100% |

**Note.** *The same article may be considered in more than one area.

The number of documents per language, highlighting that the largest production is carried out in English (96.82%). While the other languages have a low production percentage. It is confirmed that the literature specialized in the study of Neuroscience and sports performance prefers the English language.

For the number of citations in response to the country, it is detailed that the most cited countries are England (81 documents and 2092 citations), Germany (68 documents and 1326 citations), the United States (56 documents and 1267 citations), and Australia (54 documents and 1275 citations) (Figure 9).

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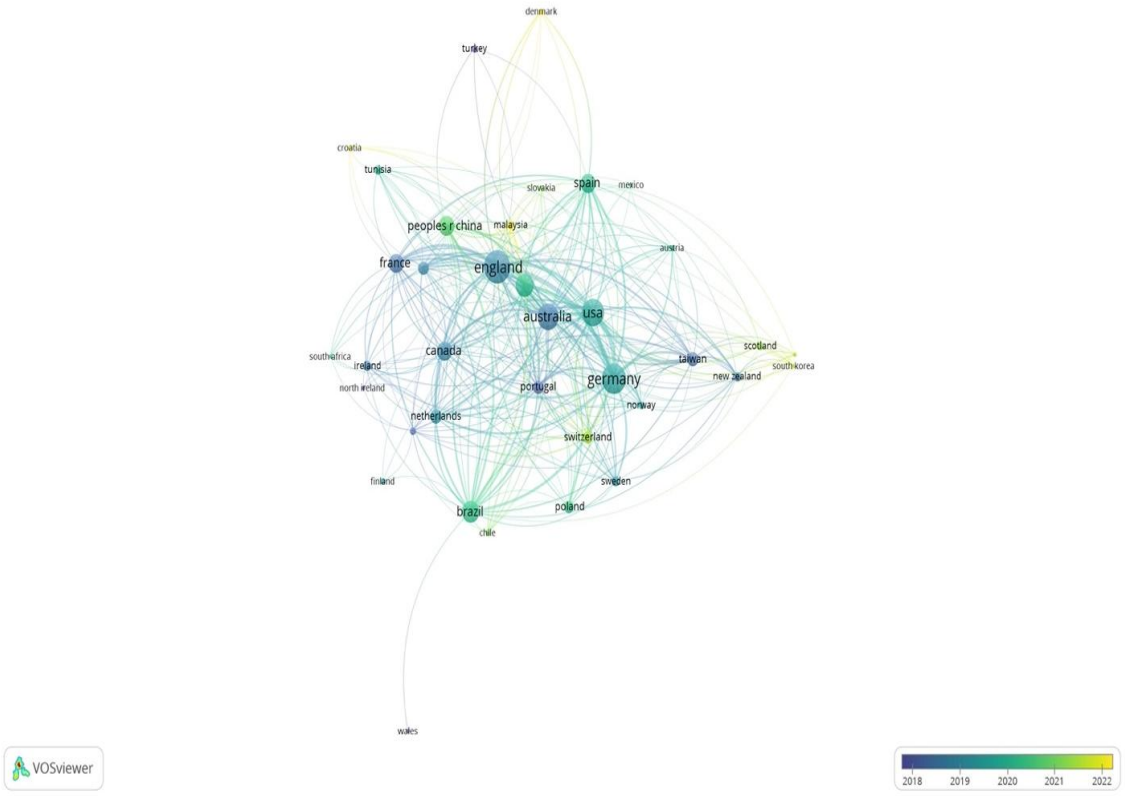
**Figure 9.** Map of citations for the different countries depending on temporality.




### *3.9. Analysis of organizations and institutions*

Taking as reference the organizations that participated in the selected studies, 701 organizations were identified, of which only 88 institutions have at least three documents and 10 citations. There, it is defined that the institutions that have received the most citations are "German Sport University Cologne" (25 documents and 851 citations) and "Queensland University Technology" (11 documents and 464 citations) (Figure 10).

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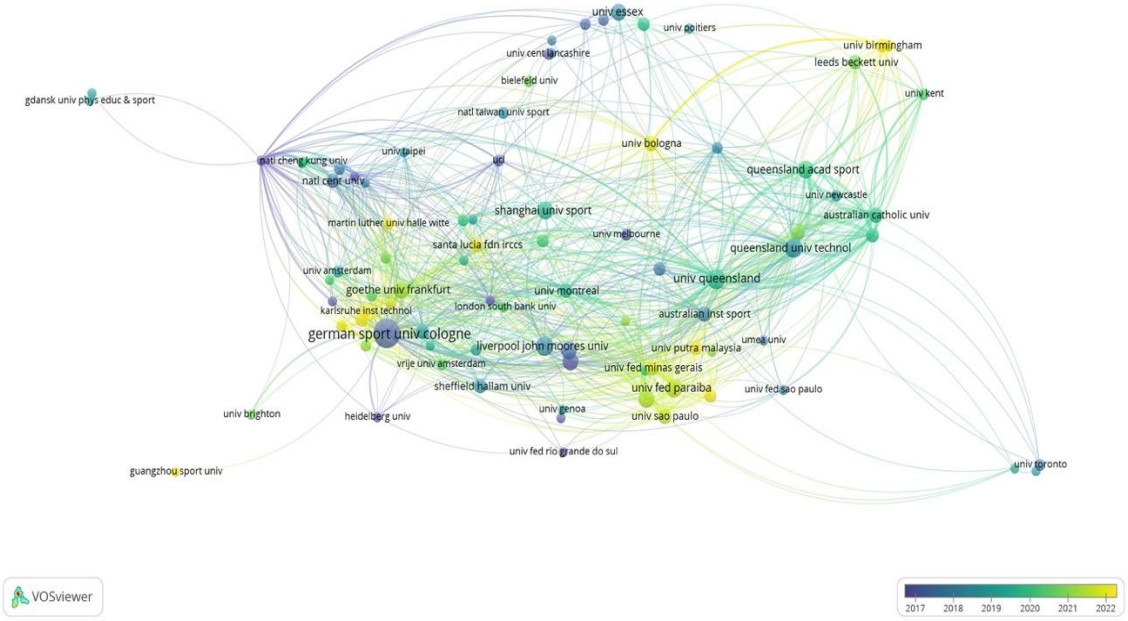
**Figure 10.** Map of total citations about organizations.




## 4. Discussion

This study aimed to analyze the evolution and trend in the number of publications related to the study of Neuroscience and Sports performance over the past 15 years (2010-2024). For this purpose, a bibliometric analysis of the studies obtained in the WoS, Scopus, and PubMed databases was carried out. The relationship between neuroscience and sports performance is a burgeoning field that seeks to understand how brain function and structure influence athletic abilities. This interdisciplinary research combines cognitive neuroscience, neurophysiology, and sports sciences to explore how neural processes support motor skills, perceptual abilities, and overall sports performance. The development of a bibliometric review allows authors and researchers to identify the state of the art of a topic, as well as to establish new gaps and poorly worked thematic lines, allowing the development of new theoretical, quantitative, and qualitative research work (Gámez-Calvo et al., 2024; Gutiérrez-Hellín et al., 2023; Hernández-Beltrán et al., 2023). In addition, it allows us to know the main current lines of research related to the object of study.

From the literature review conducted, it is observed that the integration of neuroscience with sports performance reveals that elite athletes possess unique neural adaptations that support their superior motor and perceptual skills. In addition, it suggests

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that neuroscience is closely related to sports performance through brain-tracking activity, the integration of cognitive and motor skills, pain education, and advanced neurodiagnostic techniques. Furthermore, the cognitive and affective benefits of exercise underscore the importance of brain function in sports. The main results reflect that the greatest knowledge production between neuroscience and its relationship with sports performance occurs in research articles (*n*=336, 82.15%) and review articles (*n*=62, 15.15%). It can also be observed that the number of publications remained low from the year of the first referenced study in 2010 until 2015 (13.69%) and, from 2016 onwards, there is an exponential growth except for the year 2021, which could be related to the period of the global COVID pandemic in 2020, where major sporting events and experimental research suffered an abrupt interruption due to government strategies related to social isolation. Then, between 2022 and 2023, there was a considerable increase (32.02%), with 2023 being the year with the highest production (16.62%) (Figure 2). Therefore, the number of works related to the study of the influence of mental factors on the sports performance of athletes should increase, as better results are produced as neural activity increases due to psychoneurological and physiological aspects of the NS (Benítez-Sillero et al., 2021).

Figure 2 shows the increase in the number of documents per year and the corresponding number of citations. An increase in citations up to the year 2019 (*n*=869 citations) is detailed and a decrease in the number of articles and scientific documents available in the database. These findings draw attention to the interest aroused in the scientific community for neuroscience in sports performance, as the constant search to improve sports performance, whether individual or collective, during the preparation period and in competitions, has intensified over the years. In this sense, coaches and researchers are getting in-depth answers to different mechanisms related to neuroscience, cognitive processes, fatigue, and decision-making in athletes (Quarta et al., 2020). Fortes, L.S., and Russell, S., are the authors with the highest number of studies (*n*=6). The first author presents a research focus on neuroscience and human performance. His main contributions seek to analyze the effect of central (mental fatigue, perceptual-cognitive training) and peripheral manipulation (neuromuscular fatigue and ischemic preconditioning) on the performance of athletes at different competitive levels (Fortes et

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al., 2017; 2021). The second author (Russell, S.) focuses his research on mental fatigue, recovery, and cognitive performance and has mainly established working relationships with international experts in the field (Russell, Jenkins, Rynne, et al., 2019). The author prioritizes the well-being of athletes and promotes initiatives that support mentally healthy and sustainable sports environments (Russell, Jenkins, Smith, et al., 2019).

Regarding the areas of knowledge that have been occupied by publications related to neuroscience and sports performance, it is found that "Sport Sciences", "Psychology", and "Neuroscience" account for more than a third (84.33%) of the published documents. This fact shows the interdisciplinarity of the studies developed, as well as the identification of many areas and topics that can be developed in the analysis of neuroscience and its influence on the sports performance of players. These results are consistent with the journals in which these studies have been published, all of which are indexed in quartiles 1 and 2. "Frontiers in Psychology" (Switzerland), "Psychology of Sport and Exercise" (Netherlands), "European Journal of Sport Science" (United Kingdom), "Journal of Sport Sciences" (United Kingdom), and "International Journal of Sports Physiology and Performance" (USA) stand out. These journals are ranked among the top 50% of the best journals in their fields. Carrying out publications on these platforms will allow authors to receive a high impact from their studies and increase the visibility and knowledge of the results and conclusions established (Martínez Molina, 2023).

Another relevant fact about scientific production is publishers that publish scientific knowledge. In the present study, "Taylor & Francis", "Frontiers", "Elsevier", and "MDPI" published more than a fraction of the total production (54.27%). Among them, "Frontiers" and "MDPI" are open-access publishers, while "Taylor & Francis" and "Elsevier" have some open-access journals. Open access promotes greater dissemination of relevant knowledge due to the wide and easy access for professionals in both the scientific and practical field (Hernández Hernández et al., 2020).

The citations of any scientific material represent how influential and relevant this material is within its field of research. In our study, it was observed that more than half of the referenced documents are between 2010 and 2015, except one document from 2016. It is worth mentioning that the most cited studies were published between 2010-

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2013. Thus, the studies with the highest total number of citations and average number of citations per year are: "Open vs. Closed Skill Sports and the Modulation of Inhibitory Control" (Wang et al., 2013) and "Are Expert Athletes 'Expert' in the Cognitive Laboratory? A Meta-Analytic Review of Cognition and Sport Expertise" (Voss et al., 2010). Considering the average number of citations per year, there is another study with high averages, which, in turn, is the most recent study "3D-Multiple Object Tracking training task improves passing decision-making accuracy in soccer players" (Romeas et al. 2016). From here, the interest in approaches related to reviews, the study of Psychology, cognitive performance, and the evaluation of team sports is highlighted.

In addition to the above, for the number of citations in response to the country, it is detailed how there is a high scientific production coming from countries on four continents mainly, highlighting Germany and England for Europe, Brazil for South America, Australia for Oceania, and China for the Asian continent. Similarly, 56 countries are found, of which only 37 countries have at least 2 citations. In summary, the most cited institutions were the German Sport University Cologne (25 documents and 851 citations) and the Queensland University of Technology (11 documents and 464 citations). Keywords are essential to ensure that a scientific article is accessible, relevant, and useful to both researchers and the scientific community. In the present study, the most used keywords in the studies were: Performance", "Sport", "Decision Making", "Expertise", and "Cognition. These concepts are related to another bibliometric analysis that studied decision-making in soccer, where the concepts with the highest co-occurrence were: performance, decision-making, expertise, skill and anticipation (Paucar Uribe et al., 2025). Future studies and information searches can consider the main terms used. Therefore, when developing literature reviews, correct planning and preparation of the phases to be followed during its elaboration must be carried out, as it is one of the most fundamental pillars of such work (Thomas et al., 2023). Similarly, a correct selection of the keywords to be used in the search for documents allows the identification of a large number of works related to the objective, and, therefore, the identification and establishment of relevant conclusions related to the topic (Benito-Peinado et al., 2007).

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### *4.1. Limitations*

This study has several limitations, mainly related to the heterogeneity of the population samples and the variables associated with performance that are evaluated by neuroscience, such as: mental fatigue, decision making, cognitive processing, neuroplasticity, etc., as well as the performance characteristics evaluated in different contexts, ages and sport levels. Furthermore, the bibliometric analysis was limited to documents indexed in databases such as Wos, Scopus and Scopus; therefore, the linguistic biases of these databases should be considered. Another limitation concerns the search period, which may also limit other important findings in the study of neuroscience and sports performance. In this sense, the exclusive selection of articles indexed in JCR may limit the identification of studies to those that are not indexed in high impact journals.

## 5. Conclusions

In conclusion, this is one of the first bibliometric studies to analyze the trend of scientific production related to neuroscience and sports performance. A deeper understanding of neuroscience can help recognize the contributions to sports performance in different population groups, thus projecting future lines of research.

Neuroscience in sport has been established mainly as an interdisciplinary scientific discipline focused on the improvement of cognitive processes associated with attention, memory, mental fatigue, cognitive performance, cognitive functions and sleep. All these variables are indispensable to manifest a high sports performance.

*Future perspectives and practical applications*

In summary, research associated with neuroscience and sports performance is growing exponentially in relevant knowledge by providing new strategies and mechanisms to optimize cognitive and physical training. The development of personalized mental training programs, based on neurofeedback and other advanced technologies, that improve important cognitive functions such as attention and decision-making has been evidenced. In addition, the integration of mindfulness practices and relaxation techniques is being investigated so that athletes can manage stress and anxiety more effectively, improving their overall performance. On the other hand, neuroscience is advancing innovative strategies for recovery and rehabilitation from injuries, using technologies such as virtual reality and non-invasive brain stimulation.

Reviews. Scientific output of neuroscience in sport sciences between 2010-2024: analysis of decision making, cognitive factors and sport performance with VOSviewer
Vol. 12, n. º 1; p. 1-34, January 2026. https://doi.org/10.17979/sportis.2026.12.1.12054

These advances allow the establishment of more effective personalized recovery protocols, accelerating neural and muscular regeneration. Furthermore, research on the impact of nutrition on brain function is leading to the development of personalized diets and supplements that optimize the physical and cognitive performance of athletes. With this, significant advances in sports results are sought in athletes of different competitive levels. Finally, the transdisciplinary approach is fundamental between neuroscience and sports performance due to the inherent complexity of both fields. Collaboration between neuroscientists, sports coaches, doctors, nutritionists, and other professionals allows for a more comprehensive and holistic understanding of human performance (Becerra Patiño & Escorcia Clavijo, 2023), which could imply the development of more effective strategies and programs that address both the physical and mental aspects of performance.

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