



Development of Indian research outcomes on sports science: A bibliometric analysis using Scopus database

OPEN ACCESS

*CORRESPONDENCE

Parveen Chahal
parveenchahalcrsu@gmail.com

VOLUME 08
ISSUE 1
YEAR 2025

RECEIVED 11 November 2024
ACCEPTED 25 December 2024
PUBLISHED 19 August 2025

CITATION

Parveen Chahal, Parveen Kumar, Kuldeep Nara, Rohit Rathee, Naveen Sangwan. (2025). Development of Indian research outcomes on sports science: A bibliometric analysis using Scopus database. *The Scholars Time. A Multidisciplinary Journal of Research and Development*. 08(01).pp:12-28

COPYRIGHT

© This work is licensed under a Creative Commons Attribution 4.0 International License.

e-ISSN: 2581-6489

Website: www.thescholarstime.in
Email: editor.scholarstime@gmail.com

Parveen Chahal^{*1}, Parveen Kumar², Kuldeep Nara³, Rohit Rathee⁴, Naveen Sangwan⁵,

ABSTRACT

Purpose: This bibliometric study aims to provide a comprehensive analysis of the evolution and impact of Indian research in sports science from 1966 to 2024. **Material and Methods:** Utilizing the Scopus database, we extracted and examined bibliographic data of publications by Indian authors in sports science. VOSviewer was employed as the primary tool for co-authorship, co-occurrence, and citation analysis. The present study has also been attempted to explore the connection between publication into sports science and sports performance in terms of total Olympic medals of a nation. **Results:** Our findings reveal no significant increase in research output since 1966 to 2000. After that highlighting a marked rise in publications from 2016 onwards. The co-authorship analysis identified key researchers and collaborative networks, while the co-occurrence of keywords analysis uncovered the main research themes and emerging trends, with a notable focus on topics such as sports performance, physical fitness, and injury prevention indicating a growing trend of interdisciplinary and international collaborations. **Conclusion:** This study underscores the critical role of academic research in advancing sports science and its potential to contribute to athletic excellence. The insights gained from this bibliometric analysis can inform policymakers, researchers, and sports practitioners about the importance of fostering a robust research environment to support the development of sports science in India. The nations investing more in sports science research tend to achieve better results in the sports performance.

KEYWORDS

Bibliometric, Sports Science, Physical Education, India

¹ Research Scholar, Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

² Assistant Professor, Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

³ Professor, Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

⁴ Assistant Professor, Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

⁵ Research Scholar, Department of Physical Education, Chaudhary Ranbir Singh University, Jind, Haryana, India

INTRODUCTION

Research determines the success of a particular sector (Camomilla et al., 2018; Schenk & Miltenberger, 2019). Especially, in the field of sports science and exercise performance, research play a crucial role in enhance the performance of an athletes (Harriss A.; Atkinson G., 2019; Millet et al., 2021). Various factors such as physical, psychological, physiological and development of smart equipment (Nara et al., 2023; Nara, Kumar, Rathee, Kumar, et al., 2022; Nara & Kumar, 2023; Wang et al., 2019) used to measure real time sports performance has significant impact on athletes' outcomes (Hurst et al., 2020; Mujika et al., 2018; Richlan et al., 2023a). Various human performance laboratories have been established all over the globe to understand the mechanism of performance as well as to know the limitations of an athlete's capabilities. The research published by these laboratories/institutions have shown significant impact on sprots performance. Here are some evidences from the literature which reveals the advancement in research and technology in context of sports performance.

Recent innovations in sports science research have significantly enhanced athletic performance through the integration of advanced technologies and methodologies (Nara, Kumar, Rathee, & Kumar, 2022). Wearable technology (Godfrey et al., 2018; Kim & Chiu, 2019; Lee et al., 2016; Seçkin et al., 2023), including GPS, accelerometers (Dawson et al., 2024), and smart clothing, provides real-time monitoring of athletes' movements and physiological parameters, offering precise insights for performance optimization. Biomechanical analysis using motion capture systems (van der Kruk & Reijne, 2018) and force plates identifies inefficiencies and potential injury risks, enabling targeted improvements in technique and power (Robles-Palazón et al., 2023).

Additionally, advanced training methods like High-Intensity Interval Training (HIIT) (Karlsen et al., 2017) and periodization have optimized training regimens, while nutrigenomics and ergogenic aids have personalized nutrition plans to boost performance (Martín-Rodríguez et al., 2024). Psychological interventions such as mental skills training and biofeedback enhance focus and stress management (Lindsay et al., 2023). Recovery technologies like cryotherapy (Poignard et al., 2023) and Normatec systems (Gras, 2023) accelerate recovery, and genetic research explores the potential of gene editing and epigenetics in sports performance (Naumann et al., 2023). Data analytics and machine learning aid in performance analysis and injury prevention, while VR (Virtual Reality) (Richlan et al., 2023b) and AR (Augmented Reality) (Cossich et al., 2023) technologies create immersive training environments. Customized equipment and apparel, such as 3D-printed gear and smart insoles (Selvan et al., 2024), further enhance comfort and performance, driving sports science towards more personalized and effective methods.

The pursuit of excellence in sports performance is a significant goal for many nations, including India. Despite the country's rich sporting heritage and increasing investment in athlete development, India has historically faced challenges in achieving consistent success at the international level. Recent advancements in sports science offer new opportunities to enhance athletic performance through innovative technologies, training methodologies, and data-driven strategies. However, the extent to which these advancements are being researched and applied within the Indian context remains underexplored. In addition, an attempt has been made to explore the connection between sports performance of a country or territory in terms of total medal in Olympics and number of publications in the field of sports science.

This study aims to address this gap by conducting a bibliometric analysis of Indian research outcomes on sports science using the Scopus database. The research process focused on the following study questions: (1) how the productivity of sports science is developing in India (2) who are the main contributors (authors, University, and publications?) (3) what are the thematic areas that attract the most attention of academics? (4) what topics are emerging in the field of sports science and (5) to identify the connection between sports performance and publications of a country. By systematically examining the existing literature, the study will identify key trends, gaps,

and the overall impact of research on improving sports performance. The findings will provide valuable insights for researchers, coaches, and policymakers to develop evidence-based strategies that enhance India's competitive edge on the global stage. This analysis is crucial for understanding how effectively India is leveraging sports science to boost sports performance and what further steps can be taken to optimize athlete development and success.

Materials and Methods

The present study aimed to explore the growth of Indian research publication in the field of sports science. An attempt has also been made to search the significant relationship between growth in publication and excellence in Olympic performance of Indian territory. At present time various open access platform are available to performance citation analysis, but to ensure the quality publication in the field, Scopus database has been selected to perform the bibliometric analysis.

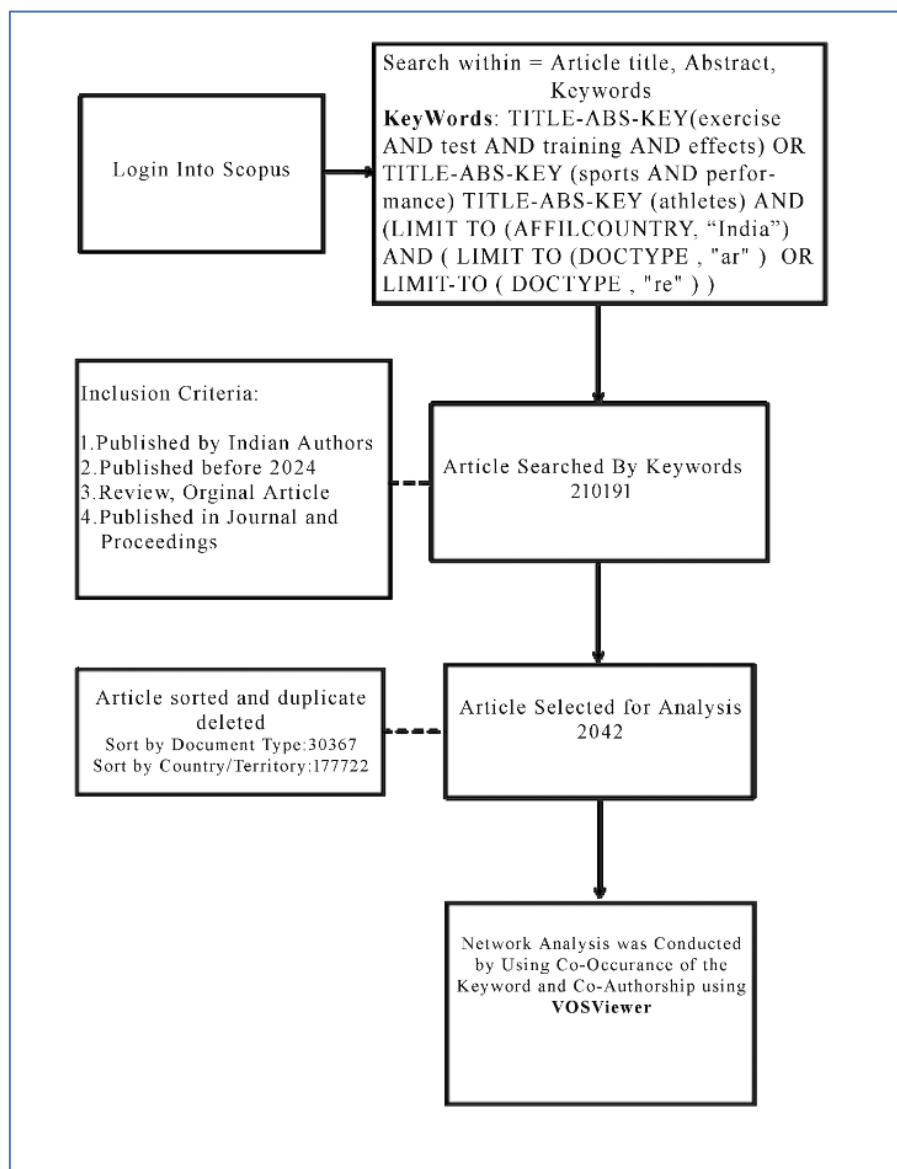


Figure 1 Search strategy for article search in Scopus database

Table 1 Inclusion and Exclusion criteria

Criterion	Inclusion	Exclusion
Keywords	(TITLE-ABS-KEY (exercise AND test AND training AND effects) OR TITLE-ABS-KEY (sports AND performance) OR TITLE-ABS-KEY (athletes)) AND (LIMIT-TO (AFFILCOUNTRY, "India")) AND (LIMIT TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re"))	Record excluded where keywords did not match the title, abstract and authors key words as well as records were excluded in absence of the relationship between the variables
Types of Literature	Journals, Review articles, Original Articles	Book, Book Series, Book Chapters
Language	English	Other than English
Time Frame	All studies before 2024	<2024
Territory	Only Indian Publication	Excluded other than Indian Authors

Source: Research Data based on Scopus Database (Extracted: 16 July 2024)

Search strategy

Scopus database was used to assess the quality articles from the field of sports science. The initial search was performed using the keywords given in Table 1 respectively. For selection of keywords, a detailed review of literature was performed in various databases. After selection of suitable or relevant keywords for the present study, the Scopus database was approached. Based on selected keywords, a total 210191 results were identified by database. To obtain the relevant studies, the obtained results were further sorted by document types (Review and Original articles) and Country/Territory, and a total 208089 results were removed. Finally, a total 2042 articles fulfil the inclusion criteria and exported through CSV file from Scopus database. The PRISMA model in Figure 1 provides a structured and transparent overview of the screening process for identifying relevant studies.

Research Design

The bibliometric analysis was performed using publication mapping and keywords occurrence analysis. This study mapped the main contributor (Author, Institution and Source name), applied a keyword occurrence analysis to find out publication trends, and trace the main thematic or topics that appeared in the publication. To present the data, the data visualization tool VOSViewer developed at Laiden University (van Eck & Waltman, 2014). Different parameter of VOSViewer software were used for analysis such as co-authorship which contain the analysis of author, organization and countries. However, the present research is delimited to Indian publication, therefore, the country analysis was not applicable. Second analysis parameter was co-occurrence which include the units of keywords and third citation analysis parameter was applied to identify the top 10 cited publication and authors, respectively. Besides the VOSViewer application, some data is directly derived from the Scopus database using analytical in the form of graphs and tables.

Results

Publication Map and Growth of Sports Science in India

The **figure 2** reveals the publication by Indian authors from 1966 to 2024 shows a significant but upward trend, especially from the mid-2000s onward. Early years (1966-1990) saw minimal publications, with gradual increases through the 1990s and early 2000s. The first ever publication including the keywords of “sports science” was published in 1966 in Indian perspective. A notable rise began in 2009, accelerating sharply from 2016 onwards, with 102 documents

published that year, and a substantial surge between 2020 and 2023, peaking at 550 documents in 2023. The trend continues in 2024 with 301 documents published so far. This growth underscore to increase in research activity and improved indexing in databases like Scopus, marking the strong need for prolific period of Indian researchers in sports science and performance analysis.

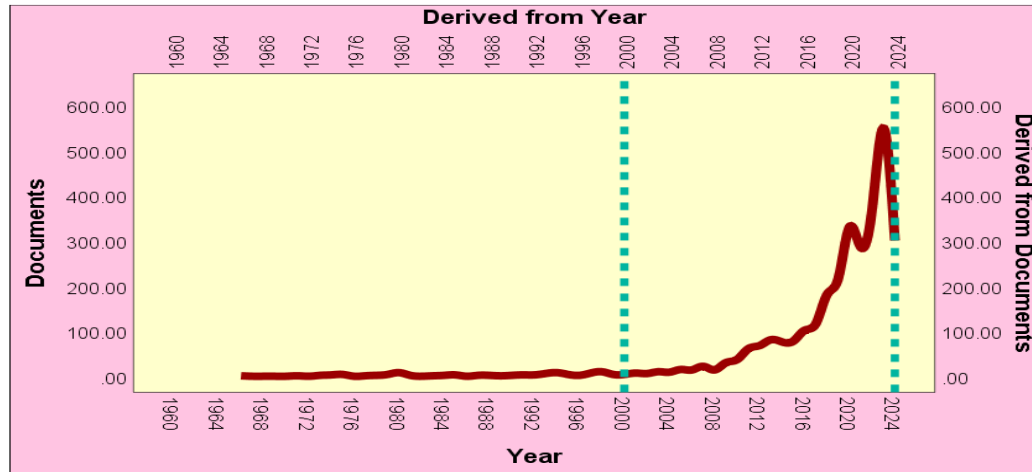


Figure 2 Publication growth in scientific literature entitled “Sports Science” from year to year (Source: Research Data based on Scopus Database (16 July 2024))

Top Contributors (authors, institutions, sources and publication)

Table 2 Documents listed in Scopus Database of different authors

Sr. No	Authors	Organization	Documents
1.	Sharma, Saurabh	Jamia Millia Islamia, New Delhi, India	25
2.	Thapa, Rohit Kumar	Symbiosis School of Sports Sciences, Pune, India	22
3.	Shenoy, D. Shweta	Guru Nanak Dev University, Amritsar, India	19
4.	Gupta, Ravi Kumar	Fortis Healthcare, Gurugram, India	17
5.	Bagchi, Amritashish	Symbiosis School of Sports Sciences, Pune, India	16
6.	Bandyopadhyay, Amit	University of Calcutta, Kolkata, India	13
7.	Kapoor, Anil	Government Medical College & Hospital, Chandigarh, India	13
8.	Karuppasamy, Govindasamy	SRM Institute of Science and Technology, Kattankulathur, India	12
9.	Masih, Gladson David	Postgraduate Institute of Medical Education & Research, Chandigarh, Chandigarh, India	12
10.	Bhati, Pooja	Shree Guru Gobind Singh Tricentenary University, Gurugram, India	10

Source: Research Data based on Scopus Database (16 July 2024)

Table 2 reveals the research contributions of the top 10 Indian authors in sports science from the Scopus database as extracted on the date of 16 July 2024, respectively. Leading the list is Saurabh Sharma from Jamia Millia Islamia University, New Delhi with around 25 publications, followed by Rohit Kumar Thapa from Symbiosis School of Sports, Pune, India and Sweta D Shenoy from Guru Nanak Dev University, Amritsar, Punjab with approximately 22 and 19 documents

respectively, indicating their significant contributions to the field. Other notable authors include Ravi Kumar Gupta from Fortis Health care Ltd. Gurugram (17 documents), Bagchi, A. (16 documents), and Bandyopadhyay, A. (13 documents). Kapoor, A. (13 documents), Govindasamy, K. (12 documents), Masih, G.D. (12 documents), and Bhati, P. (10 documents) also demonstrate active research involvement. The data underscores the prominence of these authors in advancing the field and suggests potential for robust collaborative networks among these key researchers.

Table 3 Top cited publication in the field the field of sports science

Sr. No	Document	Title	Source/Journal	Citation
1.	(Singla et al., 2018)	"Effect of upper body plyometric training on physical performance in healthy individuals: A systematic review"	Physical Therapy in Sports	55
2.	(Dhillon et al., 2017)	"Current Concepts in Sports Injury Rehabilitation"	Indian Journal of Orthopaedics	50
3.	(Thapa et al., 2021)	"Effects of Complex Training on Sprint, Jump, and Change of Direction Ability of Soccer Players: A Systematic Review and Meta-Analysis"	Frontiers in Psychology	35
4.	(Lal et al., 2023)	"Telemedicine rehabilitation and virtual reality in orthopaedics and sports medicine"	Indian Journal of Orthopaedics	18
5.	Singha, Pritam (2022)	"Shoulder internal rotator strengthening vs. muscle energy technique for shoulder external rotators on bowling speed in fast bowlers playing cricket - a quasi-experimental study"	Journal of Physiotherapy Research	14
6.	(Lal et al., 2023)	"Effects of Sand-Based Plyometric-Jump Training in Combination with Endurance Running on Outdoor or Treadmill Surface on Physical Fitness in Young Adult Males"	Journal of Sports Science and Medicine	14
7.	(Ramirez-Campillo et al., 2023)	"Effects of Plyometric Jump Training on the Reactive Strength Index in Healthy Individuals Across the Lifespan: A Systematic Review with Meta-analysis"	Sports Medicine	14
8.	(Gupta et al., 2016)	"Acute anterior cruciate ligament injuries in multisport elite players: Demography, association, and pattern in different sports"	Journal of Clinical Orthopaedics and Trauma	10
9.	(John et al., 2016)	"Epidemiological profile of sports-related knee injuries in northern India: An observational study at a tertiary care centre"	Indian Journal of Orthopaedics	10
10.	(Amrinder et al., 2014)	"Effect of plyometric training on sand versus grass on muscle soreness and selected sport-specific performance variables in hockey players"	Journal Human Sports	09

Source: Research Data based on Scopus Database (16 July 2024)

Table 3 lists the top-cited publications in the field of sports science by Indian authors, highlighting significant contributions to various aspects of sports performance and rehabilitation. The highest cited work is by Singla (2018) with 55 citations, followed by Dhillon (2017) with 50 citations, indicating a strong focus on sports injury rehabilitation and physical performance. Thapa, R.K. has two notable contributions in 2023, showcasing recent advancements in training methodologies for athletes, particularly in soccer and plyometric training, with 35 and 14 citations, respectively. Other key studies address telemedicine rehabilitation, shoulder strengthening in cricket, and injury patterns in elite athletes, reflecting diverse research interests and the growing impact of Indian sports science research on both national and international levels.

Table 4 Top Cited Research Journals in the Field of Sports and Health Sciences

Sr. No	Source	Documents	Citations
1.	British journal of sports medicine	8	886
2.	Indian journal of physiology and pharmacology	45	745
3.	journal of clinical and diagnostic research	27	386
4.	Asian journal of sports medicine	17	306
5.	Indian journal of medical research	13	299
6.	Indian journal of orthopaedics	23	187
7.	journal of back and musculoskeletal rehabilitation	9	178
8.	international journal of applied engineering research	8	153
9.	journal of clinical orthopaedics and trauma	16	149
10.	international journal of sports medicine	5	117

(Source: Research Data based on Scopus Database (16 July 2024) Analysed by VOSViewer Application)

Table 4 highlights the top-cited research journals in the field of sports and health sciences, preferred by Indian authors for publishing their research work. The British Journal of Sports Medicine leads with 8 documents and an impressive 886 citations, indicating its high influence and global relevance. The Indian Journal of Physiology and Pharmacology follows closely with 45 documents and 745 citations, showing its significant contribution to the field and preference among Indian researchers. The Journal of Clinical and Diagnostic Research and the Asian Journal of Sports Medicine also attract substantial attention, with 27 documents (386 citations) and 17 documents (306 citations) respectively. Other notable journals include the Indian Journal of Medical Research and the Indian Journal of Orthopaedics, reflecting their crucial roles in disseminating sports and health sciences research in India. The data underscores that Indian authors frequently choose these journals to publish their work, highlighting their impact and importance in advancing sports science research both nationally and internationally.

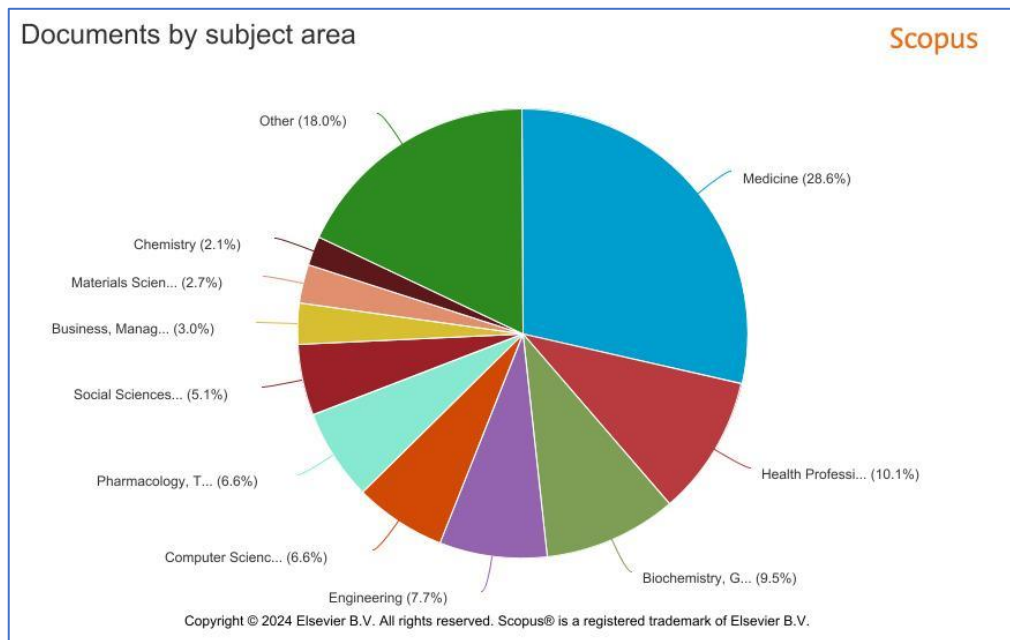


Figure 3 Distribution of Research Publications by Subject Area in Sports Science (Scopus Database, 2024)

The Figure 3 displays the distribution of research publications across various subject areas highlighting the interdisciplinary nature of sports science research. Medicine leads with 28.6%, highlighting its significant role in sports science research, particularly in sports medicine and injury rehabilitation. Health Professions contribute 10.1%, reflecting the importance of physical therapy and athletic training. Biochemistry, Genetics, and Molecular Biology account for 9.5%, focusing on the biological aspects of sports performance. Engineering (7.7%) and Computer Science (6.6%) emphasize advancements in sports technology and analytics. Pharmacology, Toxicology, and Pharmaceutics also make up 6.6%, relating to the study of performance-enhancing substances. Social Sciences contribute 5.1%, exploring the sociological aspects of sports. Smaller contributions come from Business, Management, and Accounting (3.0%) and Materials Science (2.7%), highlighting interests in sports management and equipment innovation. The Other category, at 18%, reflects the interdisciplinary nature of sports science research, integrating various fields to provide comprehensive insights.

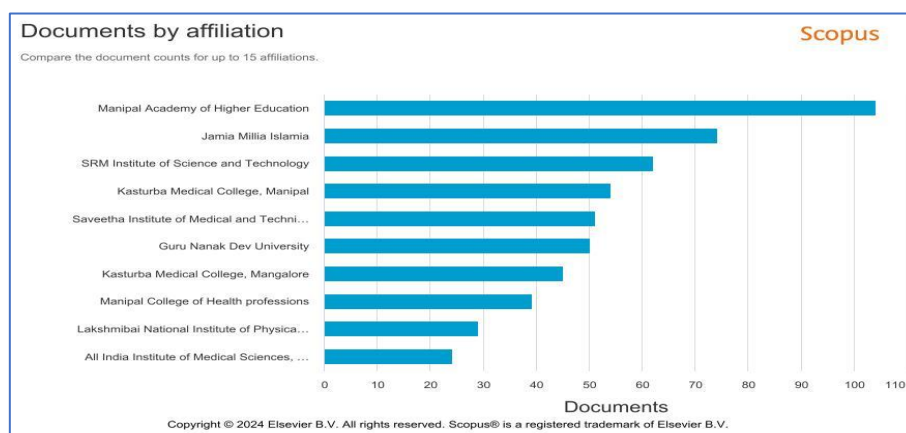


Figure 4 Leading Indian Institutions by Number of Publications in Sports Science (Scopus Database, 2024)"

The bar chart illustrates the number of documents published by various Indian institutions in the field of sports science. **Manipal Academy of Higher Education** leads with the highest number of publications, followed by **Jamia Millia Islamia University** and **SRM Institute of Science and Technology**. Other prominent institutions include **Kasturba Medical College, Manipal**, **Saveetha Institute of Medical and Technical Sciences**, and **Guru Nanak Dev University**, indicating these institutions' significant contributions to research in sports science.

Sports science as a Thematic Cluster

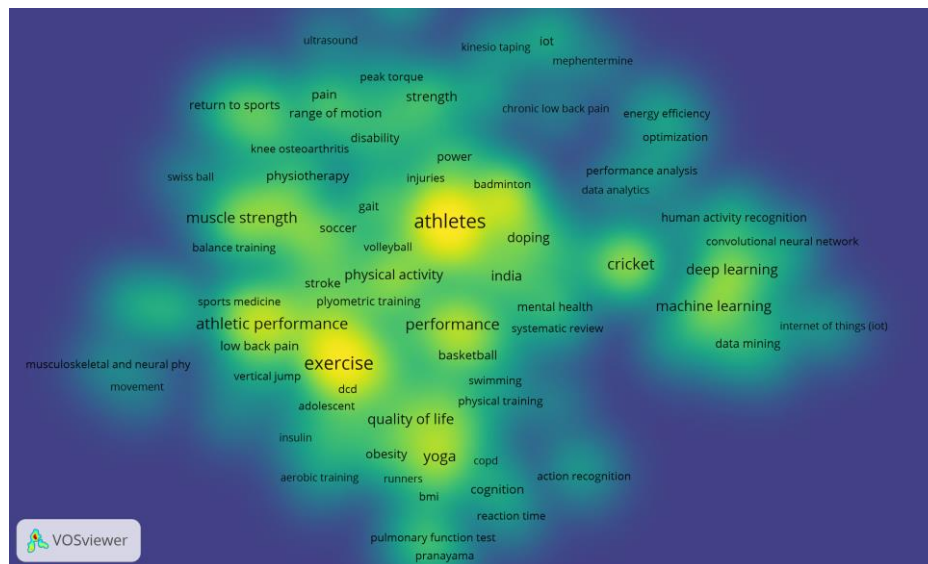


Figure 5 Density Visualization of Key Research Topics in Indian Sports Science (2000-2024) (Source: Research Data based on Scopus Database (16 July 2024) Analysed by VOSviewer Application)

The density (Figure 5) and network visualizations (Figure 6) generated using VOSviewer provide a comprehensive overview of the research landscape in Indian sports science from 2000 to 2024. The density plot highlights the most frequently occurring keywords, with terms like "athletes," "exercise," "performance," and "physical activity" standing out, indicating their central role in the research. The network visualization further elaborates on the interconnectedness of these terms, illustrating how research topics are interrelated. It shows clusters of related terms, such as "muscle strength," "athletic performance," and "yoga," connected to core themes of physical conditioning and sports performance. The presence of keywords like "machine learning," "deep learning," and "data mining" in both visualizations suggests a growing interest in integrating advanced technologies into sports science research. Additionally, traditional and region-specific interests such as "cricket" and "yoga" highlight the unique focus areas within the Indian context. Together, these visualizations reveal a multidisciplinary and evolving field, bridging health, technology, and traditional practices.



Figure 6 Network Visualization of Co-Occurrence of Keywords in Indian Sports Science Research Publications (2000-2024), highlighting interconnected themes such as 'athletes', 'performance', 'exercise', 'machine learning', and 'cricket' using VOSviewer analysis."

Table 5 High Frequency Group of Key words Associated with Sports Science Publications

Cluster Number	Number of Keywords	Keyword Occurrence
1	29	Adolescent (7); aerobic capacity (6); aerobic training (5); BMI (8); body composition (14); body mass index (8); COPD (5); exercise training (7); flexibility (11); football players (5); forced vital capacity (5); functional capacity (7); FVC (6); inspiratory muscle training (7); obesity (12); PEFR (5); physical therapy (5); Physical training (6) Pranayama (7); pulmonary function (8); pulmonary function test (8); pulmonary functions (6); quality of life (28); runners (5); running (8); sleep (5); systematic review (6); vo2max (7); yoga (35)
2	27	Artificial intelligence (12), Chronic low back pain (5), Classification (5), Clustering (6), cnn (5), computer vision (10) convolutional neural network (7), cricket (44), data analytics (5), data mining (11), deep learning (29), energy efficiency (6), feature extraction (8), feature selection (9), groin pain (5), human activity recognition (11), Indian premier league (6), internet of things (8), internet of things (iot) (8), machine learning (31), optimization (8), performance analysis (7), random forest (6), reliability (6), sports analytic (5), sports analytics (10), support vector machine (5)
3	24	ACL (8), anterior cruciate ligament (12), anterior cruciate ligament reconstruction (5), balance training (6), disability (9), dynamic balance (9), exercise therapy (7), functional performance (6), knee (9), knee joint (5), knee osteoarthritis (6), manual therapy (6), older adults (5), pain (12), physiotherapy (12), postural balance (6),

4	21	proprioception (5), rehabilitation (30), return to sports (13), soccer (12), sports injuries (7), sports injury (8), ultrasound (5), vitamin D (6), Anti-doping (6), anxiety (9), athlete (22), athletes (99), concussion (6), covid-19 (12), depression (6), dietary supplements (5), doping (19), elite athletes (5), gender (8), India (21), knowledge (6), mental health (11), me-phentermine (5), social media (9), sport (9), sports (63), stress (18), twitter (6), volleyball (7)
5	17	Anthropometry (8), badminton (9), biomechanics (12), blood pressure (7), epidemiology (7), female athletes (5), injuries (8), injury (8), kinematics (9), kinetics (5), physical activity (24), prevalence (8), prevention (6), return to sport (8), risk factors (7), sudden death (5), weightlifting (7),
6	17	Agility (26), EMG (7), endurance (20), fatigue (11), heart rate (13), insulin (5), low back pain (12), performance (41), plyometric training (9), recovery (9), speed (8), sportswear (5), sprint (5), team sports (13), vertical jump (8), VO2 max (8), women (5)
7	13	Action recognition (7), aerobic exercise (15), attention (5), basketball (12), children (6), cognition (12), core stability (5), DCD (8), heart rate variability (14), physical fitness (29), reaction time (7), sports participation (5), swimming (6),
8	13	Antioxidant (5), football (17), health (5), kabaddi (8), oxidative stress (6), peak torque (6), power (10), range of motion (16), self-efficacy (6), sports performance (16), strength (20), training (13), VO2max (5)
9	11	Balance (26), gait (10), nutrition (10), psychology (7), resistance exercise (3), smartphone (5), sports medicine (8), stroke (12), Swiss ball (5), upper extremity (8), virtual reality (6)
10	10	Athletic performance (41), exercise (76), high-intensity interval training (5), human physical conditioning (14), movement (5), muscle strength (32), musculoskeletal and neural physiological phenomena (6), plyometric exercise (17), resistance training (35), strength training (6),
11	05	Electromyography (13), IOT (11), Kinesio taping (5), muscle fatigue (5), sensors (5)
12	03	Composites (8), flexural strength (5), mechanical properties (5)

(Source: Research Data based on Scopus Database (16 July 2024) Analysed by VOSViewer Application)

Table 5 categorizes high-frequency keywords in sports science publications into clusters based on thematic similarities. Notable clusters include those focusing on fitness and health (e.g., "yoga," "quality of life"), technology and data analytics (e.g., "machine learning," "deep learning"), rehabilitation and injuries (e.g., "physiotherapy," "rehabilitation"), and mental and social aspects (e.g., "athletes," "stress"). Emerging topics identified include High Intensity Interval Training (HIIT), Plyometric Exercise, Sport Medicine, and advanced technologies like Deep Learning and Machine Learning. These emerging topics indicate a growing interest in innovative training methods and the integration of cutting-edge technology in sports science research.

Appearing Topic: Sports Science

VOSViewer application provides a visualization of a range of topics developing year to year. Figure 7 present blue, green, and yellow colours. Each colour indicates publication year of the article. Blue colour indicates the bringing of the article, while green to yellow indicate the recent publication year of the article.

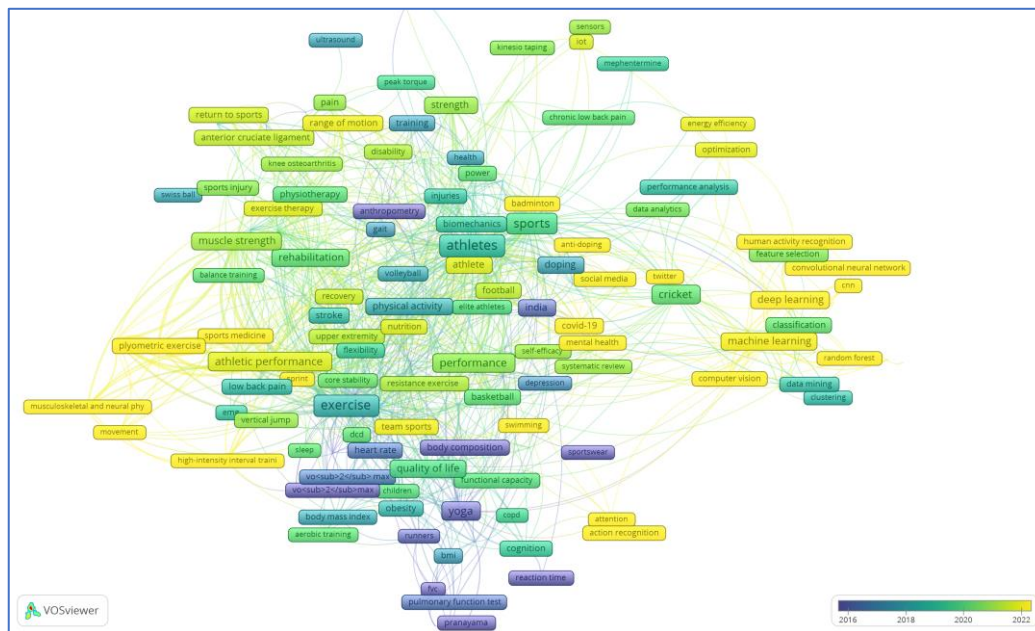


Figure 7 Average Publication Year of High Frequency Keywords in Sports Science Publication (Source: Research Data based on Scopus Database (16 July 2024) Analysed by VOSViewer Application)

The overlay visualization reveals that most keywords with recent publication date (visualize in yellow) are from cluster 7 and 10 and are placed right side of the map. While cluster 2, 4, 5, 6 contains the keywords with earliest average publication year (visualize in dark blue). The most recent publication date (2016 and so on) was assessed and sort them in table 6. Bibliometric characteristics used for further analysis including Average publication year, occurrence, link and total link strength.

Table 6 Bibliometric characteristics of recent keywords from publication in Sports Science (Sorted by date of Publication)

Sr. No	Keywords	Average Publication Year	Occurrence	Link	Total Link Strength
1.	High Intensity Interval Training	2022.60	5	14	21
2.	Plyometric Exercise	2022.24	17	21	74
3.	Sport Medicine	2022.38	8	14	27
4.	Deep Learning	2022.10	29	18	31
5.	Machine Learning	2021.84	31	25	42
6.	Athletic Performance	2021.54	41	41	113
7.	Resistance Training	2021.14	35	36	100
8.	Muscle Strength	2020.88	32	38	105
9.	Performance	2020.66	41	45	68
10.	Cricket	2020.07	44	29	42
11.	Sports	2019.62	63	65	106
12.	Athletes	2018.82	99	65	107
13.	Exercise	2018.33	76	61	137
14.	Yoga	2016.09	35	33	44
15.	Stress	2016.39	18	15	20

Source: Research Database on Scopus (16 July 2024) Analysed by VOSViewer Application

Table 6 presents the bibliometric characteristics of recent keywords from publications in sports science, sorted by their average publication year. It highlights keywords such as "High Intensity Interval Training" and "Plyometric Exercise," which have the most recent average publication years of 2022.60 and 2022.24, respectively, indicating their current relevance and emerging interest in the field. Keywords like "Deep Learning" and "Machine Learning" also appear recently, reflecting the integration of advanced technologies in sports science research. On the other hand, well-established keywords like "Athletes," "Exercise," and "Yoga" show older average publication years, but they maintain high occurrences and strong total link strengths, emphasizing their foundational importance in the field. This table provides a snapshot of trending topics and the evolution of research interests in sports science over recent years.

Discussion

The present bibliometric analysis of sports science research in India, using the Scopus database and VOSviewer for visualization, provides comprehensive insights into the evolving landscape of this multidisciplinary field. The study highlights significant trends, key contributors, and emerging research themes, reflecting the dynamic nature of sports science research in the Indian context.

In India, the first publication in Scopus data base from the filed of sports science was reported in 1966. From this point forward, no significant improvement was observed in publication up to 2000. A gradual increase was noticed between since 2000 to 2009, respectively. A significant increase in publication was depicted after 2009 and remain consistent to till date. The number of articles is too less in comparison of other territories. There are an approximately 1100 universities (including state or central) exist in India, and almost all university have a department of sports science or physical education. With this point of view the number of publications is very less. Therefore, the present study emphasizes to improve the efficiency on research work into Indian universities, specially, in the field of sports science.

The co-authorship analysis reveals that a few prolific authors, such as Sharma, S., Thapa, R.K., and Shenoy, S., have made substantial contributions to the field. These authors' high document counts suggest their pivotal role in advancing sports science research in India. After reviewing the whole list of authors with their departmental affiliations, a key point of analysis was observed that most of the authors are not affiliated to sports science and physical education background. Majority of the authors are from medical health profession. The contribution of the authors from the relevant field (sports science and physical education) are negligible. Therefore, the present findings underscore the involvement of the sports science and physical education experts in research to upgrade the athlete's performance. Furthermore, the analysis of institutional affiliations shows that leading institutions like the Manipal Academy of Higher Education, Jamia Millia Islamia, and SRM Institute of Science and Technology are central hubs of research activity. These institutions' high output underscores their commitment to sports science and their role in fostering collaborative research environments. In addition, various institute and centre of sports excellence were established all over India. For instance, Sports Authority of India (SAI) has various centres of sports training across the country. SAI is responsible to provide the adequate facility to sports person for enhance performance and various research laboratories have been established in these centres to monitor the sports performance. Unfortunately, no contribution of these sports excellence centres in terms of quality research publication has been reported in Scopus database to the till date.

The citation analysis underscores the impact of seminal works in the field. For instance, Deepika Singla's systematic review on upper body plyometric training has garnered significant attention, indicating the relevance and importance of such interventions in sports science. Similarly, studies by Dhillon on sports injury rehabilitation and Thapa on complex training effects

on soccer players have also received considerable citations, reflecting their contribution to advancing knowledge and practice in these areas.

The analysis of top-cited journals demonstrates a preference among Indian authors for publishing in reputable and high-impact journals such as the British Journal of Sports Medicine and the Indian Journal of Physiology and Pharmacology. This preference indicates an emphasis on quality and the desire for broader dissemination and recognition of their research. The present finding emphasis on the development of new Indian research journals in reference to sports science and physical education as well. In Indian perspective with reference to Scopus database, no research journal from the field of Sports Science has been identified. Therefore, the study underscore the development of quality based sources for publication.

Subject area analysis reveals that medicine, health professions, and biochemistry are the most prominent fields contributing to sports science research, accounting for significant proportions of publications. This multidisciplinary approach underscores the intersection of sports science with various fields, highlighting the holistic nature of sports research which integrates physical, biological, and social sciences.

The density and network visualizations of keyword co-occurrence provide valuable insights into the thematic evolution of sports science research. High-frequency keywords such as "athletes," "exercise," "sports," and "machine learning" reflect the core focus areas. The prominence of "machine learning" and "deep learning" indicates a growing interest in incorporating advanced analytical techniques in sports science, potentially revolutionizing performance analysis, injury prevention, and training optimization.

The analysis of average publication years for high-frequency keywords reveals an increasing trend towards recent research in areas such as "athletic performance," "resistance training," and "machine learning." This trend suggests a shift towards contemporary topics and the integration of cutting-edge technologies in sports science research, aligning with global research directions.

The findings highlight the significant contributions of key authors and institutions, the impact of high-cited publications, and the multidisciplinary nature of the field. The growing interest in advanced technologies and contemporary research themes underscores the dynamic and evolving nature of sports science, paving the way for future research that integrates traditional sports science with modern analytical techniques and interdisciplinary approaches.

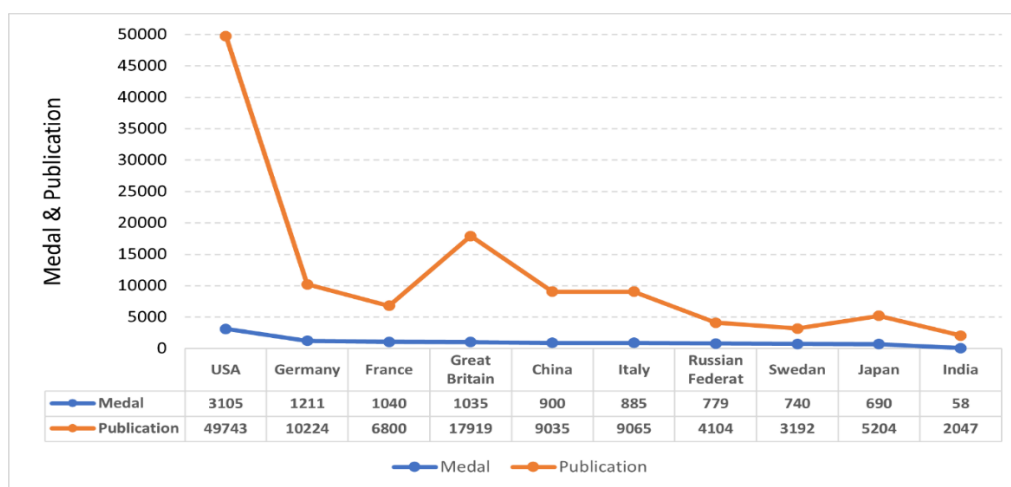


Figure 8 Line graph presents connection between publication in sports science and Olympic performance till 2020

Figure 8 depicts the relationship between the number of research publications in sports science and Olympic performance, as measured by total medal counts, for various countries (Olympedia, 2024). The graph shows a significant disparity between publication volume and medal counts. The USA, for instance, leads with 49,743 publications and 3,105 medals, indicating a strong connection between extensive research output and high Olympic performance. Conversely, countries like India, with only 2,047 publications and 58 medals, display both lower research activity and Olympic success. This trend is consistently observed across other countries, suggesting that nations investing more in sports science research tend to achieve better results in the Olympics. This data underscores the potential influence of scientific research on enhancing athletic performance and achieving success at international sporting events.

Conclusion

This bibliometric analysis of sports science research in India underscores the significant progress made in this multidisciplinary field, with key contributions from prominent authors and institutions. The growth of research publication is very low in comparisons to other developed countries. Specially, since 1966 when first publication was published to since 2000, a total 96 articles were published within a 34 years' time span. The contribution of sports science institutions in research publication are negligible, which underscore the promotion of research in higher education institutions in the field. The top authors, institutions, and research journals are affiliated to medical health profession. Therefore, the publication of sports science should be promoted in universities also. Moreover, a strong connection is also evident between publication of a country and sports performance. The nations investing more in sports science research tend to achieve better results in the sports performance.

Increasing investment in sports science, fostering interdisciplinary collaborations, and prioritizing emerging areas such as machine learning and resistance training can drive further advancements. By addressing these gaps, India can strengthen its sports science foundation, ultimately leading to improved sports performance and greater international competitiveness.

Funding: This research work did not receive any grant or funding.

Conflict of Interest: No conflict of interest was declared among authors

References

- Amrinder, S., Sakshi, G., & Singh, S. J. (2014). Effect of plyometric training on sand versus grass on muscle soreness and selected sport-specific performance variables in hockey players. *Journal of Human Sport and Exercise*, 9(1), 59–67. <https://doi.org/10.4100/jhse.2014.91.07>
- Camomilla, V., Bergamini, E., Fantozzi, S., & Vannozzi, G. (2018). Trends supporting the in-field use of wearable inertial sensors for sport performance evaluation: A systematic review. *Sensors*, 18(3), 873. <https://doi.org/10.3390/s18030873>
- Cossich, V. R. A., Carlgren, D., Holash, R. J., & Katz, L. (2023). Technological breakthroughs in sport: Current practice and future potential of artificial intelligence, virtual reality, augmented reality, and modern data visualization in performance analysis. *Applied Sciences*, 13(23), 12965. <https://doi.org/10.3390/app132312965>
- Dawson, L., McErlain-Naylor, S. A., Devereux, G., & Beato, M. (2024). Practitioner Usage, Applications, and Understanding of Wearable GPS and Accelerometer Technology in Team Sports. *The Journal of Strength & Conditioning Research*, 38(7). https://journals.lww.com/nsca-jscr/fulltext/2024/07000/practitioner_usage_applications_and.28.aspx
- Dhillon, H., Dhillon, S., & Dhillon, M. (2017). Current concepts in sports injury rehabilitation. *Indian Journal of Orthopaedics*, 51(5), 529–536. https://doi.org/10.4103/ortho.IJOrtho_226_17

- Godfrey, A., Hetherington, V., Shum, H., Bonato, P., Lovell, N. H., & Stuart, S. (2018). From A to Z: Wearable technology explained. *Maturitas*, 113, 40–47. <https://doi.org/https://doi.org/10.1016/j.maturitas.2018.04.012>
- Gras, A. (2023). *Does Intermittent Pneumatic Compression improve symptoms of Delayed Onset Muscle Soreness in Healthy Adults: a study protocol of a randomized controlled trial.*
- Gupta, R., Khanna, T., Masih, G. D., Malhotra, A., Kapoor, A., & Kumar, P. (2016). Acute anterior cruciate ligament injuries in multisport elite players: Demography, association, and pattern in different sports. *Journal of Clinical Orthopaedics and Trauma*, 7(3), 187–192. <https://doi.org/10.1016/j.jcot.2016.03.005>
- Harriss A.; Atkinson G., D. J. ; M. (2019). Ethical Standards in Sport and Exercise Science Research: 2020 Update. *International Journal of Sports Medicine*, 40(13), 813–817. <https://doi.org/10.1055/a-1015-3123>
- Hurst, P., Schipof-Godart, L., Szabo, A., Raglin, J., Hettinga, F., Roelands, B., Lane, A., Foad, A., Coleman, D., & Beedie, C. (2020). The Placebo and Nocebo effect on sports performance: A systematic review. *European Journal of Sport Science*, 20(3), 279–292. <https://doi.org/10.1080/17461391.2019.1655098>
- John, R., Dhillon, M. S., Syam, K., Prabhakar, S., Behera, P., & Singh, H. (2016). Epidemiological profile of sports-related knee injuries in northern India: An observational study at a tertiary care centre. *Journal of Clinical Orthopaedics and Trauma*, 7(3), 207–211. <https://doi.org/10.1016/j.jcot.2016.02.003>
- Karlsen, T., Aamot, I.-L., Haykowsky, M., & Rognmo, Ø. (2017). High Intensity Interval Training for Maximizing Health Outcomes. *Progress in Cardiovascular Diseases*, 60(1), 67–77. <https://doi.org/https://doi.org/10.1016/j.pcad.2017.03.006>
- Kim, T., & Chiu, W. (2019). Consumer acceptance of sports wearable technology: the role of technology readiness. *International Journal of Sports Marketing and Sponsorship*, 20(1), 109–126. <https://doi.org/10.1108/IJSMS-06-2017-0050>
- Lal, H., Mohanta, S., Kumar, J., Patralekh, M. K., Lall, L., Katariya, H., & Arya, R. K. (2023). Telemedicine-Rehabilitation and Virtual Reality in Orthopaedics and Sports Medicine. *Indian Journal of Orthopaedics*, 57(1), 7–19. <https://doi.org/10.1007/s43465-022-00766-6>
- Lee, J., Kim, D., Ryoo, H.-Y., & Shin, B.-S. (2016). Sustainable wearables: Wearable technology for enhancing the quality of human life. *Sustainability*, 8(5), 466. <https://doi.org/10.3390/su8050466>
- Lindsay, R. S., Larkin, P., Kittel, A., & Spittle, M. (2023). Mental imagery training programs for developing sport-specific motor skills: a systematic review and meta-analysis. *Physical Education and Sport Pedagogy*, 28(4), 444–465. <https://doi.org/10.1080/17408989.2021.1991297>
- Martín-Rodríguez, A., Belinchón-deMiguel, P., Rubio-Zarapuz, A., Tornero-Aguilera, J. F., Martínez-Guardado, I., Villanueva-Tobaldo, C. V., & Clemente-Suárez, V. J. (2024). Advances in Understanding the Interplay between Dietary Practices, Body Composition, and Sports Performance in Athletes. *Nutrients*, 16(4), 571. <https://doi.org/10.3390/nu16040571>
- Millet, G. P., Brocherie, F., & Burtcher, J. (2021). Olympic Sports Science—Bibliometric Analysis of All Summer and Winter Olympic Sports Research. *Frontiers in Sports and Active Living*, 3. <https://www.frontiersin.org/journals/sports-and-active-living/articles/10.3389/fspor.2021.772140>
- Mujika, I., Halson, S., Burke, L. M., Balagué, G., & Farrow, D. (2018). An Integrated, Multifactorial Approach to Periodization for Optimal Performance in Individual and Team Sports. *International*

- Journal of Sports Physiology and Performance*, 13(5), 538–561.
<https://doi.org/10.1123/ijsp.2018-0093>
- Nara, K., & Kumar, P. (2023). Aging, personality, and teaching aptitude in school grade physical education teachers. *Pedagogy of Physical Culture and Sports*, 27(4), 297–304.
<https://doi.org/10.15561/26649837.2023.0405>
- Nara, K., Kumar, P., Kumar, R., & Singh, S. (2023). Normative reference values of grip strength, the prevalence of low grip strength, and factors affecting grip strength values in Indian adolescents. *Journal of Physical Education and Sport*, 23(6), 1367–1375.
<https://doi.org/10.7752/jpes.2023.06167>
- Nara, K., Kumar, P., Rathee, R., & Kumar, J. (2022). The compatibility of running-based anaerobic sprint test and Wingate anaerobic test: a systematic review and meta-analysis. *Pedagogy of Physical Culture and Sports*, 26(2), 134–143. <https://doi.org/10.15561/26649837.2022.0208>
- Nara, K., Kumar, P., Rathee, R., Kumar, S., Ahlawat, R. P., Sharma, J., & Singh, S. (2022). Grip strength performance as a determinant of body composition, muscular strength and cardiovascular endurance. *Journal of Physical Education and Sport*, 22(7), 1618–1625.
<https://doi.org/10.7752/jpes.2022.07203>
- Naumann, N., Paßreiter, A., Thomas, A., Krug, O., Walpurgis, K., & Thevis, M. (2023). Analysis of potential gene doping preparations for transgenic DNA in the context of sports drug testing programs. *International Journal of Molecular Sciences*, 24(21), 15835.
<https://doi.org/10.3390/ijms242115835>
- Olympedia. (2024, July 10). *Medals by country*. <https://www.olympedia.org/statistics/medal/country>
- Poignard, M., Guilhem, G., Jubeau, M., Martin, E., Giol, T., Montalvan, B., & Bieuzen, F. (2023). Cold-water immersion and whole-body cryotherapy attenuate muscle soreness during 3 days of match-like tennis protocol. *European Journal of Applied Physiology*, 123(9), 1895–1909.
<https://doi.org/10.1007/s00421-023-05190-8>
- Ramirez-Campillo, R., Thapa, R. K., Afonso, J., Perez-Castilla, A., Bishop, C., Byrne, P. J., & Granacher, U. (2023). Effects of Plyometric Jump Training on the Reactive Strength Index in Healthy Individuals Across the Lifespan: A Systematic Review with Meta-analysis. *Sports Medicine*, 53(5), 1029–1053.
<https://doi.org/10.1007/s40279-023-01825-0>
- Richlan, F., Weiß, M., Kastner, P., & Braid, J. (2023a). Virtual training, real effects: a narrative review on sports performance enhancement through interventions in virtual reality. *Frontiers in Psychology*, 14. <https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.1240790>
- Richlan, F., Weiß, M., Kastner, P., & Braid, J. (2023b). Virtual training, real effects: a narrative review on sports performance enhancement through interventions in virtual reality. *Frontiers in Psychology*, 14. <https://www.frontiersin.org/journals/psychology/articles/10.3389/fpsyg.2023.1240790>
- Robles-Palazón, F. J., Comfort, P., Ripley, N. J., Herrington, L., Bramah, C., & McMahon, J. J. (2023). Force plate methodologies applied to injury profiling and rehabilitation in sport: A scoping review protocol. *Plos One*, 18(10), e0292487. <https://doi.org/10.1371/journal.pone.0292487>
- Schenk, M., & Miltenberger, R. (2019). A review of behavioral interventions to enhance sports performance. *Behavioral Interventions*, 34(2), 248–279.
<https://doi.org/10.1002/bin.1659>
- Seçkin, A. Ç., Ateş, B., & Seçkin, M. (2023). Review on Wearable Technology in sports: Concepts, Challenges and opportunities. *Applied Sciences*, 13(18), 10399.
<https://doi.org/10.3390/app131810399>

- Selvan, S., Jayaraman, S., Varadharajan, S., Rajendran, M., Palanivel, E., & Kumaresan, J. (2024). Smart Shoes for Fitness and Performance Analysis of Sportsmen. *2024 IEEE International Conference on Computing, Power and Communication Technologies (IC2PCT)*, 5, 552–557. <https://doi.org/10.1109/IC2PCT60090.2024.10486538>
- Singla, D., Hussain, M. E., & Moiz, J. A. (2018). Effect of upper body plyometric training on physical performance in healthy individuals: A systematic review. *Physical Therapy in Sport*, 29, 51–60. <https://doi.org/10.1016/j.ptsp.2017.11.005>
- Thapa, R. K., Lum, D., Moran, J., & Ramirez-Campillo, R. (2021). Effects of Complex Training on Sprint, Jump, and Change of Direction Ability of Soccer Players: A Systematic Review and Meta-Analysis. *Frontiers in Psychology*, 11. <https://doi.org/10.3389/fpsyg.2020.627869>
- van der Kruk, E., & Reijne, M. M. (2018). Accuracy of human motion capture systems for sport applications; state-of-the-art review. *European Journal of Sport Science*, 18(6), 806–819. <https://doi.org/10.1080/17461391.2018.1463397>
- van Eck, N. J., & Waltman, L. (2014). Visualizing Bibliometric Networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring Scholarly Impact: Methods and Practice* (pp. 285–320). Springer International Publishing. https://doi.org/10.1007/978-3-319-10377-8_13
- Wang, H., Li, L., Chen, H., Li, Y., Qiu, S., & Gravina, R. (2019). Motion Recognition for Smart Sports Based on Wearable Inertial Sensors. In L. Mucchi, M. Hämmäläinen, S. Jayousi, & S. Morosi (Eds.), *Body Area Networks: Smart IoT and Big Data for Intelligent Health Management* (pp. 114–124). Springer International Publishing.