



# From athlete monitoring to responsible decision support in sports analytics: A bibliometric and thematic analysis of applied sport science (2015–2025)

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## ABSTRACT

Sports analytics has become increasingly central to applied sport science, yet its conceptual development remains unevenly theorized. This study mapped the evolution of sports analytics research from 2015 to 2025 using a Scopus-based bibliometric analysis of 1,211 documents. Descriptive bibliometrics, co-authorship analysis, country collaboration mapping, keyword co-occurrence analysis, trend-topic analysis, bibliographic coupling, and co-citation analysis were used to examine the field's development, conceptual structure, and intellectual foundations. Findings show that sports analytics has expanded rapidly and is increasingly organized around athlete monitoring, performance analysis, machine learning, training load, artificial intelligence, and decision support. The literature reflects a shift from descriptive measurement toward predictive and computationally mediated forms of applied sport science. However, this growth also exposes unresolved tensions involving model interpretability, data quality, ethical governance, and the translation of analytics into practice. To address this, the study proposes a responsible and integrative framework that positions sports analytics as an interconnected system of data capture, computational processing, human interpretation, applied performance action, and ethical governance. The review argues that sports analytics becomes meaningful only when technological sophistication is aligned with valid, interpretable, and athlete-centred decision-making.

**Keywords:** Sports analytics, Applied sport science, Athlete monitoring, Performance analysis, Machine learning, Decision support systems, Bibliometric analysis, Training load.

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## INTRODUCTION

Sports analytics has become an increasingly important part of applied sport science, not only because sport now produces more data, but because these data are being used to inform how performance, workload, fatigue, readiness, and decision-making are understood (Kang & Lee, 2025). Earlier methodological work already anticipated that large and complex datasets could reshape both the practice and knowledge base of sport science, while player-tracking scholarship showed that modern performance environments increasingly depend on the integration of multiple technologies rather than on isolated measures (Buchheit & Simpson, 2017; Passfield & Hopker, 2017). This development is consequential because analytics changes the function of data within sport settings. Data are no longer collected only to describe what happened after training or competition. They are increasingly used to support prospective judgments about adaptation, risk, tactical demands, recovery, and intervention. In this sense, sports analytics reflects a broader movement in applied sport science from fragmented measurement toward integrated, model-supported, and decision-oriented practice (Davis et al., 2024; Wilson & Kiely, 2023).

Conceptual clarity is important because sports analytics, performance analysis, and athlete monitoring are related but not identical constructs. Sports analytics is best understood as a broader analytical framework concerned with collecting, processing, modelling, interpreting, and translating sport data into actionable knowledge (Dello Iacono et al., 2026). Performance analysis is more specifically concerned with the evaluation of sport performance, often through technical, tactical, behavioural, biomechanical, or match-related indicators (Hughes & Bartlett, 2002). In contrast, athlete monitoring focuses on tracking athlete status over time, including workload, fatigue, readiness, recovery, physiological response, and adaptation (Timmerman et al., 2024). These constructs overlap in practice, but they operate at different levels of scope. Performance analysis and athlete monitoring generate important streams of evidence, while sports analytics provides the broader system through which those streams can be integrated, modelled, interpreted, and used for decision-making. This distinction is necessary because the growing visibility of sports analytics should not be reduced to either match analysis or workload tracking alone. Its significance lies in how it reorganizes multiple forms of sport evidence into a connected analytical and practical system.

This shift is especially visible in athlete monitoring, where analytics now operates as an applied decision process rather than a simple record-keeping activity. Coaches and support staff use monitoring primarily to reduce injury and illness, inform training programs, and maintain or improve performance, showing that monitoring is valued for its practical relevance to decision-making rather than for data collection alone (Timmerman et al., 2024). Recent work on athlete monitoring systems similarly shows that these platforms are increasingly designed to centralize the integration, processing, analysis, and visualization of diverse monitoring inputs (Burger et al., 2024). However, the growing availability of data does not automatically lead to better practice. Monitoring systems remain dependent on data quality, standardization, visualization, communication, and practitioner interpretation (Saw et al., 2015; Thornton et al., 2019). Therefore, the development of sports analytics should be understood not simply as a technical expansion, but as a shift toward decision architecture in applied sport science, where data become meaningful only when they support valid, interpretable, and context-sensitive action.

At the same time, the field is being reshaped by rapid computational development. Artificial intelligence is increasingly applied across biomechanics, performance enhancement, sports medicine, health monitoring, coaching, and talent identification, while deep learning has shown potential for automating performance analysis and extracting patterns from complex sport environments (Jia et al., 2025; Zhou et al., 2025). These developments indicate that many sport-performance problems are increasingly being reframed as problems

of classification, prediction, pattern recognition, optimization, and decision support. This computational turn has considerable promise, particularly for injury-risk modelling, workload interpretation, movement recognition, tactical analysis, and performance forecasting. Yet it also introduces important conceptual and practical tensions. Analytical sophistication does not guarantee interpretability, ethical acceptability, or real-world usefulness. Recent discussions of artificial intelligence and technology use in sport emphasize continuing concerns related to model validation, data heterogeneity, transparency, bias, workflow integration, privacy, and accountability (Kim et al., 2025; Naughton et al., 2024; Reis et al., 2024). Thus, the maturation of sports analytics depends not only on more powerful models, but also on stronger theoretical, ethical, and translational foundations.

Despite this momentum, the broader knowledge structure of sports analytics in applied sport science remains insufficiently synthesized. Existing mapping efforts have tended to focus on narrower subdomains, such as training-load monitoring in athletes or artificial-intelligence applications in specific sports, rather than the wider field spanning monitoring, performance analysis, coaching, computational modelling, and decision support (Hasan et al., 2024; Sampaio et al., 2024). This gap matters because without a broader bibliometric account, it remains difficult to determine whether sports analytics is merely expanding in publication volume or consolidating into a coherent conceptual and intellectual domain. More importantly, it remains unclear how the field's major strands can be integrated into a responsible framework that accounts for data capture, computational processing, human interpretation, applied performance action, and ethical governance. Accordingly, the present study maps sports analytics research in applied sport science from 2015 to 2025 through a bibliometric analysis of trends, conceptual development, and intellectual structure. Beyond mapping publication growth, collaboration patterns, keyword networks, trend topics, bibliographic coupling, and co-citation structure, the study contributes a responsible and integrative framework for sports analytics. This proposed framework positions sports analytics as an interconnected system whose value depends not only on technological sophistication, but on the valid collection, responsible processing, human interpretation, practical translation, and ethical governance of athlete and performance data.

## **METHODS**

### ***Research design***

This study employed a bibliometric research design to map the development, collaborative structure, conceptual organization, and intellectual foundations of research (Jiang et al., 2025; Öztürk et al., 2024) on sports analytics in applied sport science. The analysis focused on literature related to athlete monitoring, workload monitoring, performance analytics, training analytics, data-driven coaching, data-informed training, and decision support systems in sport science, exercise science, and strength and conditioning. Bibliometric analysis was appropriate because it enables the systematic examination of publication patterns, citation relationships, collaboration networks, and thematic structures within a defined research field (Hoang, 2025).

### ***Data source and search strategy***

Table 1 summarizes the search strategy and inclusion parameters of the study. The bibliographic data were retrieved from the Scopus database, which was selected because it provides structured and comprehensive metadata suitable for bibliometric analysis. The search was performed using the TITLE-ABS-KEY field to capture records whose titles, abstracts, or keywords directly aligned with the focus of the study. Boolean operators, phrase searching, truncation, and exclusion terms were used to maximize topical relevance while minimizing unrelated records. The search was restricted to English-language publications and to the document types of article, review, and conference paper. The final corpus covered publications from 2015 to 2025.

Table 1. Search strategy and inclusion parameters.

Parameter	Description
Database & indexes	Scopus
Search field	TITLE-ABS-KEY TITLE-ABS-KEY ("sport analytics" OR "sports analytics" OR "performance analytics" OR "training analytics" OR "data-driven training" OR "data driven training" OR "data-informed training" OR "data informed training" OR "data-driven coaching" OR "data driven coaching" OR "data-informed coaching" OR "data informed coaching" OR "athlete monitoring" OR "workload monitoring" OR "decision support system*") AND (athlete* OR coach* OR coaching OR "sport science" OR "sports science" OR "exercise science" OR "strength and conditioning") AND (analytic* OR monitor* OR predict* OR model* OR workload OR performance OR decision*) AND NOT TITLE-ABS-KEY (marketing OR sponsorship OR consumer* OR gambling OR betting OR "fantasy sport*" OR finance OR economic*) AND (LIMIT-TO LANGUAGE , "English") AND LIMIT-TO DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re") OR LIMIT-TO (DOCTYPE , "cp")
Search string	
Language	English
Document types	Article, review, conference paper
Excluded themes	Marketing, sponsorship, consumer behaviour, gambling, betting, fantasy sports, finance, and economics
Final timespan of corpus	2015-2025

### **Eligibility criteria and corpus delimitation**

Records were included if they matched the search strategy and were indexed as articles, reviews, or conference papers. These document types were retained because they represent the most established and analysable forms of scholarly output in bibliometric studies. Records outside the topical scope of the study, as well as document types beyond the retained categories, were excluded. After screening and final cleaning, the dataset comprised 1,211 documents published across 518 sources and authored by 4,222 authors. The corpus included 839 articles, 293 conference papers, and 79 reviews.

### **Data cleaning and preprocessing**

The retrieved records were screened and cleaned prior to analysis to improve consistency and analytical reliability. This process involved removing document types outside the retained categories and checking bibliographic fields for formatting inconsistencies that could affect descriptive summaries and network construction. Keyword expressions were also reviewed to reduce fragmentation caused by spelling, hyphenation, and closely related variants. For conceptual interpretation, Author's Keywords were prioritized over broader indexing terms when thematic clarity was required.

### **Bibliometric analysis**

The cleaned dataset was analysed using Bibliometrix/Biblioshiny for descriptive bibliometric outputs and VOSviewer for science mapping and network visualization. Descriptive analysis was used to summarize the overall profile of the field, including publication growth, source productivity, author productivity, citation characteristics, document composition, and collaboration indicators. To examine the structure of the field, several bibliometric techniques were employed. (1) Co-authorship analysis was used to identify collaboration patterns among authors; (2) Co-occurrence analysis was conducted to map the conceptual structure of the field based on recurring keyword relationships; (3) Bibliographic coupling analysis at the source level was used to identify links among publication outlets based on shared references, thereby revealing contemporary thematic proximities; (4) Co-citation analysis was used to identify the intellectual structure of the field by examining which cited items were frequently referenced together; In addition (5) country collaboration mapping was used to visualize international research linkages; while (6) trend topic analysis was used to examine the temporal prominence of recurring themes.

**Network thresholds and visualization parameters**

Thresholds were selected to balance inclusiveness with interpretive clarity. Rather than maximizing the number of displayed items, the study retained thresholds that yielded cleaner and more analytically meaningful network structures. The final thresholds were set at a minimum of three (3) documents for co-authorship analysis, ten (10) occurrences for keyword co-occurrence analysis, five (5) documents for bibliographic coupling at the source level, and twenty (20) citations for co-citation analysis. In the network maps, nodes represented authors, keywords, sources, or cited items depending on the analysis performed, while links represented the strength of association between nodes. Node size reflected relative prominence, and colours indicated clusters of closely related items.

**Framework development**

Following the bibliometric analyses, a responsible and integrative framework was developed through interpretive synthesis of the study findings. The framework was informed by the keyword co-occurrence, trend-topic, bibliographic coupling, and co-citation analyses, which collectively showed how sports analytics is organized around athlete monitoring, computational modelling, decision support, applied performance action, and governance concerns. Rather than serving as a separate statistical output, the framework represents a theory-oriented synthesis of the mapped field, positioning sports analytics as an interconnected system of data capture, analytical processing, human interpretation, practical translation, and ethical governance.

**Ethical considerations**

This study has been exempted for ethical review by the Bulacan State University-Ethics Research Committee (BulSU-ERC) with Protocol No. BulSUERC-2026-0160-EX.

**RESULTS****Descriptive profile and publication growth**

The final bibliometric dataset comprised 1,211 documents published between 2015 and 2025, distributed across 518 sources and authored by 4,222 scholars. The corpus was composed primarily of articles ( $n = 839$ ), followed by conference papers ( $n = 293$ ) and reviews ( $n = 79$ ). Overall, the dataset showed an annual growth rate of 24.02%, a document average age of 4.06 years, and an average of 14.80 citations per document. Across all retrieved records, a total of 39,979 references were recorded. In terms of collaboration, the field demonstrated a relatively strong multi-authored pattern, with 4.56 co-authors per document, 66 single-authored documents, and 27.09% international co-authorship. These indicators suggest that research on sports analytics in applied sport science has developed into a rapidly expanding, collaborative, and increasingly visible area of scholarship. The annual scientific production further showed that the field experienced substantial growth across the study period (see Figure 1). During the earlier years of the corpus, publication output remained modest, but the number of documents increased progressively over time and accelerated markedly in the later years, particularly from the early 2020s onward. The sharp upward trend in recent years indicates that sports analytics has moved beyond a niche area of inquiry and has become a more established research domain within applied sport science. This growth likely reflects the increasing integration of data-driven approaches in athlete monitoring, performance optimization, workload assessment, and decision-making processes in sport settings.

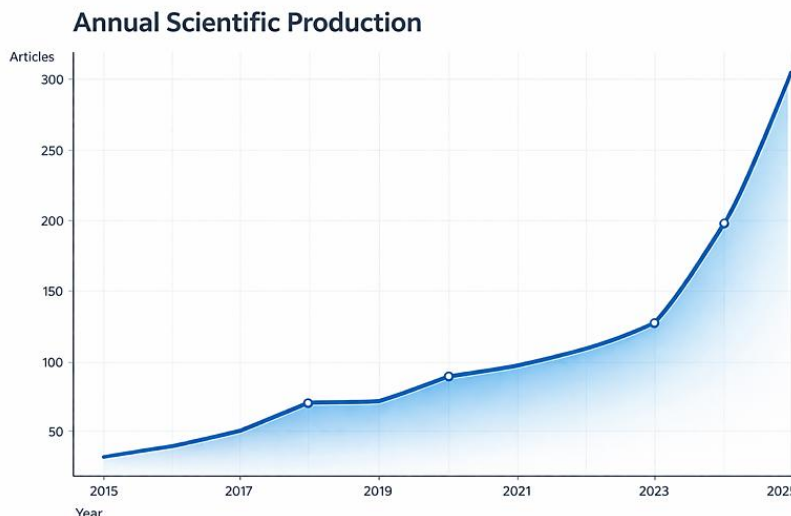


Figure 1. Annual scientific production in applied sport science research on sports analytics (2015–2025).

**Leading sources, authors, affiliations, and influential documents**

As can be seen in Table 2, the source distribution indicates that research on sports analytics in applied sport science is concentrated in journals with strong orientations toward performance, athlete monitoring, coaching, and applied physiology. The *Journal of Strength and Conditioning Research* was the most productive source with 79 documents, followed by the *International Journal of Sports Science and Coaching* with 69 documents and the *International Journal of Sports Physiology and Performance* with 49 documents. Other notable sources included *Sports* (31 documents), the *Journal of Sports Sciences* (24 documents), *Frontiers in Sports and Active Living* (22 documents), and *Sensors* (22 documents). This pattern suggests that the field is largely anchored in performance-focused and practice-oriented publication outlets, reflecting the applied nature of sports analytics within sport science.

Table 2. Most relevant sources (2015–2025).

Sources / Journal	Number of articles
Journal of Strength and Conditioning Research	79
International Journal of Sports Science and Coaching	69
International Journal of Sports Physiology and Performance	49
Sports	31
Journal of Sports Sciences	24
Frontiers in Sports and Active Living	22
Sensors	22
Journal of Functional Morphology and Kinesiology	15
Applied Sciences (Switzerland)	14
European Journal of Sport Science	14

In terms of author productivity, a relatively small group of scholars contributed prominently to the growth of the field, as shown in Table 3. Stone, M.H. emerged as the most productive author with 27 publications, followed by Coutts, A.J. (15) and Robertson, S. (13). Other leading contributors included Bunn, J.A. (11), as well as Cabarkapa, D., Esco, M.R., and Fry, A.C., each with 10 publications. These patterns suggest that the field is characterized by a core group of highly productive authors, indicating a degree of intellectual concentration and sustained research engagement in performance science, athlete monitoring, and analytics-related work.

Table 3. Most relevant authors (2015–2025).

Author	Number of articles
Stone, M.H.	27
Coutts, A.J.	15
Robertson, S.	13
Bunn, J.A.	11
Cabarkapa, D.	10
Esco, M.R.	10
Fry, A.C.	10
Ishida, A.	9
Jagim, A.R.	9
Jones, M.T.	9

At the institutional level, the most productive affiliations further reinforce the applied and performance-centred profile of the literature, as presented in Table 4. East Tennessee State University emerged as the leading affiliation with 38 documents, followed by Deakin University (25) and The Ohio State University (24). More broadly, the distribution of the top affiliations indicates that Australia and the United States serve as the principal institutional hubs of research activity in this field. Of the ten most productive affiliations, six were based in Australia and three were based in the United States, highlighting the concentration of institutional scholarship within these countries. This suggests that the field is being shaped primarily by universities with strong orientations toward athlete monitoring, high-performance sport, strength and conditioning, and sport technology.

Table 4. Most relevant affiliations (2015–2025).

Affiliation	Number of articles
East Tennessee State University, USA	38
Deakin University, Australia	25
The Ohio State University, USA	24
Edith Cowan University, Australia	22
Victoria University, Australia	22
Australian Catholic University, Australia	17
University of Technology Sydney, Australia	17
George Mason University, USA	16
La Trobe University, Australia	16
Leeds Beckett University, UK	16

The citation profile within the analysed corpus, based on local citations, revealed several documents with strong internal influence on the development of the field, as summarized in Table 5. Saw et al. (2016) emerged as the most cited document in the corpus with 61 citations, followed by R. Gathercole, Sporer, et al. (2015) with 28 citations and Thorpe et al. (2017) with 26 citations. Additional documents with notable corpus-level influence included studies by Rein and Memmert (2016), R. J. Gathercole et al. (2015), Sarlis and Tjortjjs (2020), Robertson et al. (2017), R. J. Gathercole, Stellingwerff, et al. (2015), Heishman et al. (2020), and Schneider et al. (2018). Collectively, these documents indicate that the internal citation structure of the field is anchored in research on athlete monitoring, workload management, performance evaluation, and the application of analytical approaches to sport decision-making.

Taken together, the patterns observed across sources, authors, affiliations, and corpus-level citation influence suggest that research on sports analytics in applied sport science has developed within a relatively concentrated yet expanding scholarly community. The prominence of performance-oriented journals, recurring author contributors, productive institutional hubs, and internally influential documents indicates that

the field is being shaped by a shared applied focus on athlete monitoring, workload assessment, performance evaluation, and data-informed decision-making. Building on this productivity and influence profile, the next section examines how these scholarly actors are connected through collaborative relationships at both the author and country levels.

Table 5. Most cited documents in the corpus (2015–2025).

Source	Total citations	Global citations
Saw, A. E., Main, L. C., & Gatin, P. B. (2016). Monitoring the athlete training response: Subjective self-reported measures trump commonly used objective measures: a systematic review. <i>British Journal of Sports Medicine</i> , 50(5), 281–291. <a href="https://doi.org/10.1136/bjsports-2015-094758">https://doi.org/10.1136/bjsports-2015-094758</a>	61	719
Gathercole, R., Sporer, B., Stellingwerff, T., & Sleivert, G. (2015). Alternative Countermovement-Jump Analysis to Quantify Acute Neuromuscular Fatigue. <i>International Journal of Sports Physiology and Performance</i> , 10(1), 84–92. <a href="https://doi.org/10.1123/ijsp.2013-0413">https://doi.org/10.1123/ijsp.2013-0413</a>	28	339
Thorpe, R. T., Atkinson, G., Drust, B., & Gregson, W. (2017). Monitoring Fatigue Status in Elite Team-Sport Athletes: Implications for Practice. <i>International Journal of Sports Physiology and Performance</i> , 12(s2), S2-27-S2-34. <a href="https://doi.org/10.1123/ijsp.2016-0434">https://doi.org/10.1123/ijsp.2016-0434</a>	26	255
Rein, R., & Memmert, D. (2016). Big data and tactical analysis in elite soccer: Future challenges and opportunities for sports science. <i>SpringerPlus</i> , 5(1), 1410. <a href="https://doi.org/10.1186/s40064-016-3108-2">https://doi.org/10.1186/s40064-016-3108-2</a>	18	437
Gathercole, R. J., Sporer, B. C., Stellingwerff, T., & Sleivert, G. G. (2015). Comparison of the Capacity of Different Jump and Sprint Field Tests to Detect Neuromuscular Fatigue. <i>Journal of Strength and Conditioning Research</i> , 29(9), 2522–2531. <a href="https://doi.org/10.1519/JSC.0000000000000912">https://doi.org/10.1519/JSC.0000000000000912</a>	17	199
Sarlis, V., & Tjortjis, C. (2020). Sports analytics—Evaluation of basketball players and team performance. <i>Information Systems</i> , 93, 101562. <a href="https://doi.org/10.1016/j.is.2020.101562">https://doi.org/10.1016/j.is.2020.101562</a>	16	152
Robertson, S., Bartlett, J. D., & Gatin, P. B. (2017). Red, Amber, or Green? Athlete Monitoring in Team Sport: The Need for Decision-Support Systems. <i>International Journal of Sports Physiology and Performance</i> , 12(s2), S2-73-S2-79. <a href="https://doi.org/10.1123/ijsp.2016-0541">https://doi.org/10.1123/ijsp.2016-0541</a>	16	99
Gathercole, R. J., Stellingwerff, T., & Sporer, B. C. (2015). Effect of Acute Fatigue and Training Adaptation on Countermovement Jump Performance in Elite Snowboard Cross Athletes. <i>Journal of Strength and Conditioning Research</i> , 29(1), 37–46. <a href="https://doi.org/10.1519/JSC.0000000000000622">https://doi.org/10.1519/JSC.0000000000000622</a>	15	116
Heishman, A. D., Daub, B. D., Miller, R. M., Freitas, E. D. S., Frantz, B. A., & Bembien, M. G. (2020). Countermovement Jump Reliability Performed With and Without an Arm Swing in NCAA Division 1 Intercollegiate Basketball Players. <i>Journal of Strength and Conditioning Research</i> , 34(2), 546–558. <a href="https://doi.org/10.1519/JSC.00000000000002812">https://doi.org/10.1519/JSC.00000000000002812</a>	14	165
Schneider, C., Hanakam, F., Wiewelhove, T., Döweling, A., Kellmann, M., Meyer, T., Pfeiffer, M., & Ferrauti, A. (2018). Heart Rate Monitoring in Team Sports—A Conceptual Framework for Contextualizing Heart Rate Measures for Training and Recovery Prescription. <i>Frontiers in Physiology</i> , 9, 639. <a href="https://doi.org/10.3389/fphys.2018.00639">https://doi.org/10.3389/fphys.2018.00639</a>	13	165

### **Collaborative structure of the field**

The collaborative structure of research on sports analytics in applied sport science reflects a field that is both actively networked and selectively clustered (see Figure 2). As shown earlier, the dataset had an average of 4.56 co-authors per document and 27.09% international co-authorship, indicating that collaboration is a defining feature of publication in this area. To examine this pattern more closely, a co-authorship analysis

was conducted using a minimum threshold of 3 documents per author. Although 231 authors met this threshold, only 52 authors formed connected items in the final network, suggesting that the field is characterized by a combination of established collaborative groups and a larger number of authors who remain outside the main connected structure. The map further shows that Stone, M.H. occupied the most visually prominent node, suggesting a highly visible collaborative presence within the author network.

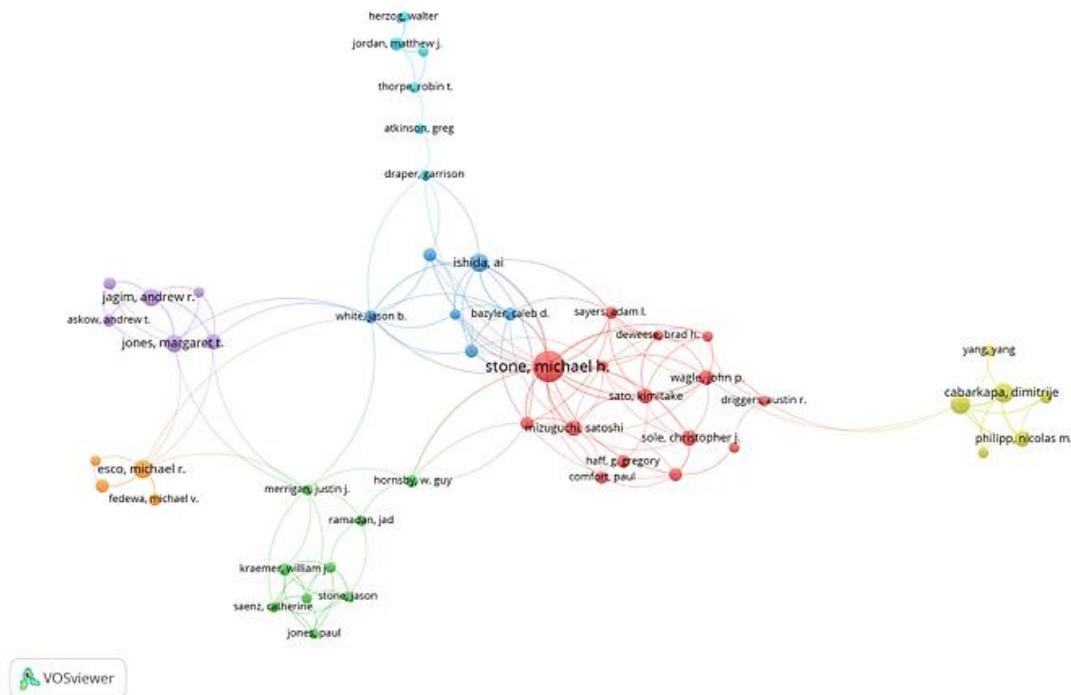


Figure 2. Co-authorship network of authors in applied sport science research on sports analytics (2015–2025).

The co-authorship map revealed several distinct collaboration clusters rather than a single fully integrated authorship network. This indicates that research in sports analytics is being advanced through multiple author groups working around related but not necessarily identical lines of inquiry, such as athlete monitoring, workload management, performance testing, and applied sport science support. The presence of cluster-based collaboration suggests that the field is developing through semi-concentrated scholarly communities, where repeated co-publication among familiar research teams appears to play an important role in knowledge production. At the same time, the limited number of connected authors relative to those meeting the publication threshold points to a degree of fragmentation, implying that the field has not yet fully matured into a broadly unified collaboration structure.

The country collaboration data further indicate that the field has developed through a clearly international research network, with particularly visible ties among countries in North America, Europe, Oceania, and Asia (see Figure 3). The strongest recorded collaboration link was between Australia and the United Kingdom ( $f = 27$ ), followed by the USA and Australia (24), the USA and the United Kingdom (20), and the USA and Canada (16). Other notable cross-national collaborations included Australia and Canada (11), Spain and Italy (11), Australia and New Zealand (10), USA and India (10), and both United Kingdom-Canada and United Kingdom-Ireland collaborations (9 each). Additional visible ties such as Australia-Spain (9), USA-Brazil (8), and United Kingdom-Germany, United Kingdom-Italy, United Kingdom-Netherlands, and USA-Spain (7



the intersection of applied athlete-support practices and data-driven analytical methods. The network further shows that athlete monitoring is closely linked with terms such as “workload,” “team sports,” “head impact,” and “performance assessment,” while the sports analytics cluster connects with “machine learning,” “classification,” “data mining,” “prediction modelling,” and “decision support.” A related performance-analysis grouping includes “data analysis” and “video analysis,” highlighting the continuing importance of observational and technical evaluation in sport performance. These patterns suggest that the field’s conceptual structure is anchored in a practical tension between traditional sport science concerns and newer computational approaches, with sports analytics increasingly functioning as the link between monitoring, modelling, and applied decision-making.

Table 6 further highlights the conceptual profile of the field by identifying the most frequent Author’s Keywords in sports analytics research. Machine learning emerged as the most frequent keyword and also recorded the highest total link strength, indicating its strong conceptual prominence in the literature. This was followed by sport analytics, performance analysis, and deep learning, suggesting that the field is increasingly shaped by the integration of computational methods with performance-focused inquiry. At the same time, keywords such as training load, sports science, GPS, and fatigue show that the literature remains closely tied to applied concerns related to workload monitoring, athlete assessment, and performance management.

Table 6. Most frequent Author’s Keywords in applied sport science research on sports analytics (2015–2025).

Rank	Author’s Keyword	Occurrences	Total link strength
1	Machine learning	93	141
2	Sport analytics	75	81
3	Performance analysis	67	106
4	Deep learning	51	74
5	Training load	44	78
6	Sports science	41	82
7	Soccer	40	68
8	Performance	36	82
9	GPS	36	79
10	Fatigue	26	59

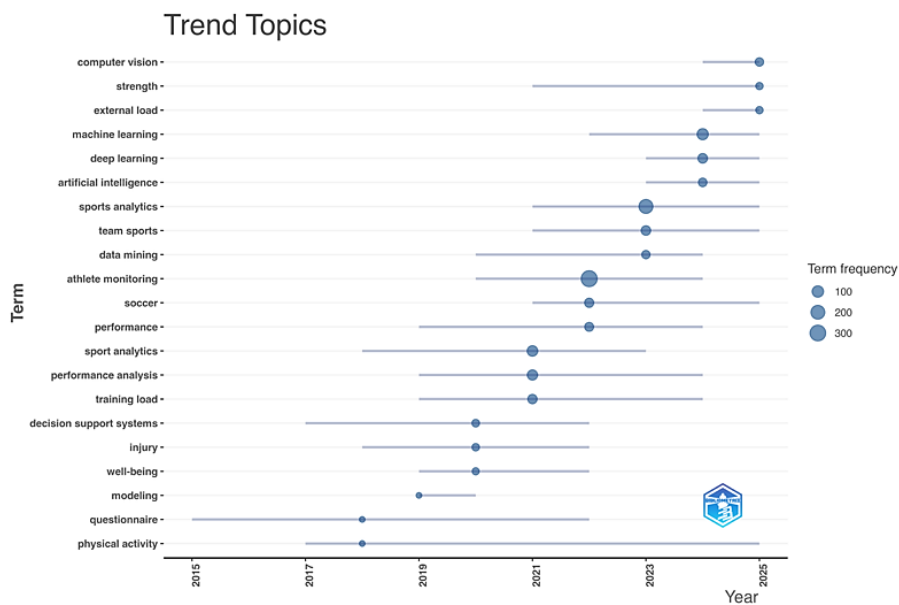


Figure 5. Trend topics on applied sport science research on sports analytics (2015–2025).



comprising twenty (20) sources, was labelled “*applied sport science, rehabilitation, and performance support*.” Representative outlets in this group included Applied Sciences (Switzerland), Biology of Sport, and BMC Sports Science, Medicine and Rehabilitation. This cluster suggests a strong contemporary emphasis on applied sport science research that connects performance support with broader rehabilitation and practitioner-oriented concerns.

The second cluster, consisting of eight (8) sources, was labelled “*exercise physiology, athlete monitoring, and athletic training*,” represented by sources such as International Journal of Exercise Science, International Journal of Sport Physiology and Performance, and Journal of Athletic Training. This grouping reflects a more focused intellectual space centred on physiological monitoring, training responses, and athlete care.

The third cluster, with six (6) sources, was labelled “*coaching, sport performance, and applied sport science practice*” and included International Journal of Sports Science and Coaching, Journal of Science and Medicine in Sport, and Journal of Sports Sciences. This cluster points to a practice-facing body of literature concerned with coaching, performance enhancement, and field-based sport science applications.

The fourth major cluster, consisting of four (4) sources, was labelled “*physiology, active living, and interdisciplinary sport health research*,” represented by Frontiers in Physiology, Frontiers in Sports and Active Living, and International Journal of Environmental Research and Public Health. This cluster suggests that part of the field is also connected to wider interdisciplinary work involving physiology, public health, and active-living perspectives.

Table 7. Bibliographic coupling clusters of sources in applied sport science research on sports analytics (2015–2025).

Cluster	Theme	Sources (n)	Representative sources
1	Applied sport science, rehabilitation, and performance support	20	Applied Sciences (Switzerland); Biology of Sport; BMC Sports Science, Medicine and Rehabilitation
2	Exercise physiology, athlete monitoring, and athletic training	8	International Journal of Exercise Science; International Journal of Sport Physiology and Performance; Journal of Athletic Training
3	Coaching, sport performance, and applied sport science practice	6	International Journal of Sports Science and Coaching; Journal of Science and Medicine in Sport; Journal of Sports Sciences
4	Physiology, active living, and interdisciplinary sport health research	4	Frontiers in Physiology; Frontiers in Sports and Active Living; International Journal of Environmental Research and Public Health

The co-citation analysis, using a minimum threshold of twenty citations, complemented the bibliographic coupling results by identifying the shared knowledge base of the field. While bibliographic coupling captured contemporary source-level affinities (Takahashi et al., 2023), co-citation analysis revealed the references that are repeatedly cited together and therefore function as the field’s intellectual foundations (Small, 1973). The resulting structure shows that sports analytics in applied sport science remains grounded in work on athlete monitoring, workload assessment, fatigue profiling, performance evaluation, and data-informed training support (see Figure 7). This indicates that even as the field becomes more computationally sophisticated, its foundational literature continues to be anchored in practical sport science concerns related to managing athlete status, interpreting performance demands, and supporting applied decision-making.



patterns, training responses, and tactical possibilities before they become visible through conventional observation (Claudino et al., 2019; Cust et al., 2019; Leckey et al., 2025). However, prediction should not be treated as automatic truth. Predictive authority becomes fragile when models are trained on narrow datasets, poorly validated, difficult to interpret, or detached from the realities of sport practice. Therefore, the field's next challenge is not only to build more advanced models, but to ensure that prediction remains transparent, context-sensitive, and practically meaningful (Reis et al., 2024; Zhou et al., 2025).

### ***The human–technology tension in analytics-informed practice***

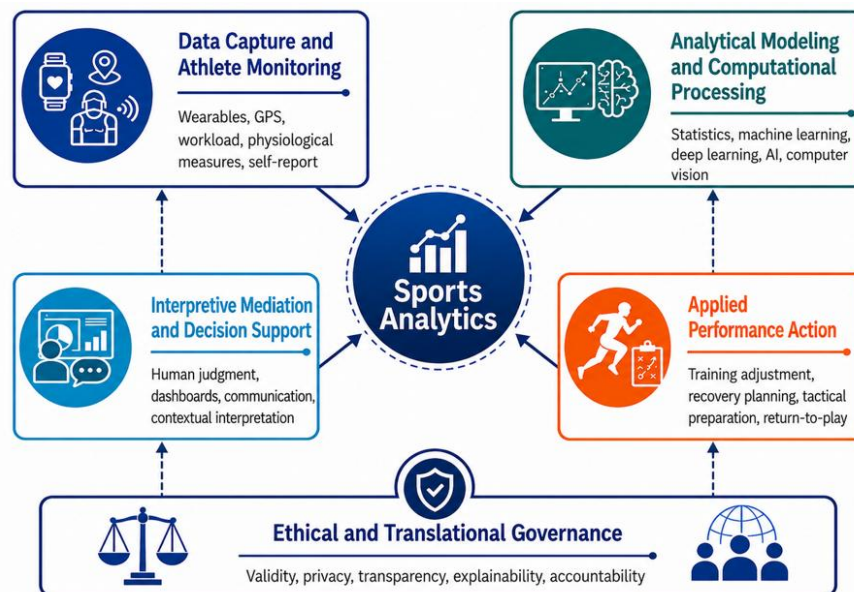
The rise of sports analytics also reveals a persistent human–technology tension in applied sport science. Although the field increasingly depends on automated systems, dashboards, wearable technologies, and decision-support platforms, the interpretation of these outputs remains deeply human. Sport is not a closed technical environment where data can simply produce action. Coaches, athletes, sport scientists, and medical staff make decisions under uncertainty, time pressure, emotional demands, and organizational constraints. This means that analytical systems should be treated as interpretive aids rather than substitutes for professional judgment (Wilson et al., 2025). Human-centred AI scholarship reinforces this point by arguing that trustworthy technologies must preserve human agency, accountability, and meaningful control (Shneiderman, 2020). In sport settings, this is particularly important because even highly sophisticated tracking systems may vary in quality, validity, reliability, and practical usability (Robertson, Duthie, et al., 2023; Robertson, Zender, et al., 2023). Thus, sports analytics is most valuable when it strengthens practitioner reasoning, supports collaborative sense-making, and helps professionals ask better questions. It becomes problematic only when dashboards or algorithms begin to replace contextual judgment rather than refine it (Hecksteden et al., 2023; Naughton et al., 2024).

### ***The risk of reducing athletes into data profiles***

The final critical issue concerns the risk that increasingly powerful analytics may reduce athletes into data profiles. This risk does not diminish the value of sports analytics, but it reminds the field that athlete data are partial representations rather than complete accounts of human performance. A readiness score, GPS output, fatigue index, workload value, injury-risk category, or algorithmic classification may reveal important patterns, but it does not fully capture the athlete as an embodied, psychological, relational, and situational person. This concern becomes more important as AI and machine-learning systems gain influence in performance evaluation, injury prediction, and athlete monitoring. Ethical discussions in sport already highlight issues of privacy, bias, transparency, accountability, and responsible data use (Kim et al., 2025). Broader work on explainable and interpretable AI likewise warns that black-box systems are problematic when their outputs influence high-stakes human decisions (Barredo Arrieta et al., 2020; Rudin, 2019). For sports analytics to mature responsibly, it must remain athlete-centred and interpretively humble. In this regard, its future contribution should not be defined only by predictive accuracy, but by its ability to support better decisions without allowing the athlete to disappear behind the metric.

### ***Toward a responsible and integrative framework for sports analytics***

This study proposes a responsible and integrative framework for sports analytics in applied sport science. The proposed framework positions sports analytics not as a single method, technology, or computational technique, but as an interconnected system through which athlete data are captured, processed, interpreted, translated into action, and governed ethically. Its central contribution is the integration of five dimensions: (a) data capture and athlete monitoring, (b) analytical modelling and computational processing, (c) interpretive mediation and decision support, (d) applied performance action, and (e) ethical and translational governance. These dimensions clarify how sports analytics can advance applied sport science while avoiding a narrow technological view of athlete performance.



Note: The framework positions sports analytics as the central hub through which athlete monitoring, analytical modelling, interpretive decision support, and applied performance action are integrated in applied sport science. The solid arrows indicate the contribution of these four operational components to sports analytics, while the dashed connectors show ethical and translational governance as a foundational layer that guides the responsible use of data, models, interpretation, and practice. The model emphasizes that sports analytics becomes meaningful only when data are validly collected, responsibly processed, humanly interpreted, practically translated, and ethically governed.

Figure 8. Responsible and integrative framework for sports analytics in applied sport science.

### ***Data capture and athlete monitoring***

This forms the evidentiary base of sports analytics. In applied sport science, this involves the systematic collection of athlete-related information through monitoring systems, wearable devices, GPS units, physiological measures, workload indicators, self-report tools, and performance-tracking technologies. Theoretically, this reflects the field's movement toward more continuous and multidimensional evidence generation. Practically, however, monitoring should not be reduced to collecting as many indicators as possible. The value of athlete data depends on whether the selected measures are aligned with the performance question, the sport context, the athlete's training phase, and the practitioner's decision needs. Internal and external load remain useful distinctions because they help clarify both what athletes do and how they respond to imposed demands (Impellizzeri et al., 2019). Yet monitoring becomes meaningful only when data are organized, visualized, and communicated in ways that support practical interpretation rather than overwhelm decision-makers (Thornton et al., 2019; Timmerman et al., 2024).

### ***Analytical modelling and computational processing***

This convert athlete data into structured outputs that can support interpretation, prediction, and decision-making. This includes statistical modelling, machine learning, deep learning, computer vision, AI, and other computational approaches used to identify patterns, classify movements, estimate risk, or forecast performance outcomes. Theoretically, this component explains why sports analytics is becoming more than descriptive performance analysis; it introduces predictive and pattern-recognition capacities that extend what can be observed through conventional sport science methods. Practically, computational processing can support injury-risk modelling, tactical analysis, movement recognition, training-response estimation, and workload interpretation (Claudino et al., 2019; Cust et al., 2019). However, its value depends on

methodological discipline. A model may appear technically advanced but remain weak if it is trained on narrow datasets, poorly validated, difficult to interpret, or detached from the applied context in which it will be used. For this reason, analytical outputs should be evaluated not only for accuracy, but also for transparency, transferability, contextual relevance, and usefulness in real sport settings (Davis et al., 2024; Reis et al., 2024; Zhou et al., 2025).

### ***Interpretive mediation and decision support***

This emphasizes that analytics does not move automatically from data to action. Between computational output and practical decision-making lies the interpretive work of coaches, sport scientists, athletic trainers, medical staff, and athletes themselves. This is where analytics becomes humanly meaningful. A fatigue score, load warning, readiness profile, or injury-risk estimate may guide attention, but it still needs to be interpreted in relation to athlete history, competition schedule, psychological state, tactical role, recovery capacity, and coaching priorities. Theoretically, this component places human judgment at the centre of sports analytics and resists the assumption that algorithmic outputs are self-explanatory. Practically, it frames dashboards and decision-support systems as tools for sharpening practitioner reasoning rather than replacing it. Recent work on AI implementation in sport science and sport medicine highlights the importance of workflow integration, communication, trust, and user readiness in translating analytical outputs into practice (Naughton et al., 2024). Human-centred AI also reinforces the need to preserve meaningful human control and accountability when technologies influence high-stakes decisions (Shneiderman, 2020).

### ***Applied performance action***

This refers to the translation of analytics into practical intervention. This includes modifying training loads, adjusting recovery strategies, informing return-to-play decisions, designing individualized conditioning programs, preparing tactical plans, identifying performance trends, and communicating athlete needs across multidisciplinary teams. Theoretically, this component shows that sports analytics becomes fully meaningful only when it enters the applied cycle of action, evaluation, and refinement. Practically, it prevents analytics from becoming a detached reporting exercise. Data dashboards, predictive models, and monitoring reports should lead to clearer questions, better discussions, and more defensible decisions. This aligns with the movement from descriptive to prescriptive analytics in elite sport, where data are expected to guide training management rather than merely summarize prior performance (Houtmeyers et al., 2021). It also reflects the growing role of sport scientists in translating evidence into organizational decision support (Ward et al., 2019). However, applied action should remain cautious and iterative. Analytics should support professional experimentation, reflection, and adjustment rather than create rigid prescriptions that ignore athlete variability and context.

### ***Ethical and translational governance***

Ethical and translational governance cuts across the entire framework because sports analytics involves human data, institutional decisions, and practical consequences. Athlete data are not neutral objects. They are collected from bodies, interpreted within performance systems, and used to make decisions that may affect workload, health, privacy, selection, opportunity, and career development. Theoretically, this component situates sports analytics within broader concerns about responsibility, fairness, transparency, and athlete-centred practice. Practically, it requires clear standards for data quality, consent, privacy protection, bias reduction, explainability, data security, and accountability. These concerns become especially important as AI and machine-learning systems become more influential in sport settings, where opaque outputs may shape high-stakes decisions without being fully understood by users (Barredo Arrieta et al., 2020; Rudin, 2019). Ethical analyses of AI in sport similarly emphasize privacy, fairness, transparency, and responsible implementation as central issues for the field (Kim et al., 2025). In this proposed framework, governance

ensures that sports analytics remains practically transferable, ethically defensible, and athlete-centred rather than merely technologically impressive.

## **CONCLUSION**

This study shows that sports analytics in applied sport science has developed from a dispersed technical area into a more visible and conceptually organized field shaped by athlete monitoring, performance analysis, machine learning, AI, decision support, and workload management. Beyond documenting growth, the study contributes a responsible and integrative framework that positions sports analytics as a connected system of data capture, computational processing, human interpretation, applied performance action, and ethical governance. The central implication is that sports analytics becomes meaningful not through data volume or technological sophistication alone, but through its capacity to support valid, interpretable, context-sensitive, and athlete-centred decisions in real sport settings.

### ***Implications for research, practice, and technology development***

The study carries implications for researchers, practitioners, and technology developers working within applied sport science. For researchers, the findings suggest that sports analytics should be examined not only as a set of computational tools, but as an emerging analytical framework that is reshaping how evidence, prediction, and decision-making are conceptualized in sport. Therefore, future scholarly work should give greater attention to model validation, interpretability, methodological transparency, data quality, and the contextual limits of predictive claims. For practitioners, the study emphasizes that analytics should support professional judgment rather than replace it. Athlete monitoring systems, dashboards, workload indicators, and predictive models are most useful when they help coaches, sport scientists, athletic trainers, and performance staff make better-informed decisions about training, recovery, readiness, injury risk, and performance planning. For technology developers, the proposed framework highlights the need to design systems that are not only technically powerful, but also usable, explainable, ethically responsible, and aligned with the realities of sport practice. The practical value of sports analytics depends on whether its outputs can be interpreted, communicated, and translated into action without reducing athletes to data profiles or allowing algorithmic recommendations to override contextual expertise.

### ***Limitations***

This study should be interpreted within several methodological boundaries. The analysis was limited to Scopus-indexed English-language publications, which provided a structured and high-quality bibliographic dataset but may have excluded relevant studies indexed in other databases, non-English publications, books, technical reports, policy documents, and industry-based analytics work. This limitation is important because sports analytics is a rapidly developing field where some innovations may emerge first in professional sport organizations, technology companies, conference proceedings, or practitioner-oriented outlets before appearing in indexed journal literature. As with other bibliometric studies, the findings were also shaped by database coverage, search-string design, author keyword practices, citation age, source-title variation, and metadata quality, despite screening and data-cleaning procedures. Citation indicators may favour older documents, while newer work on AI, computer vision, athlete data governance, and explainable analytics may not yet have accumulated strong citation influence. Finally, bibliometric mapping can identify publication trends, collaboration patterns, conceptual structures, and intellectual foundations, but it cannot directly assess the methodological rigor, practical effectiveness, ethical quality, or real-world implementation success of individual analytics systems.

### **Future research directions**

Future research should move beyond mapping the expansion of sports analytics and examine how analytical systems actually shape decision-making in applied sport environments. Additional focused reviews are needed on specific subdomains such as athlete monitoring, AI, computer vision, training-load analytics, decision-support systems, injury-risk prediction, and return-to-play analytics. Comparative bibliometric studies using multiple databases may also clarify whether the intellectual structure identified in this study remains stable across different indexing systems and publication cultures. Empirical research should examine how coaches, sport scientists, athletes, medical staff, and performance leaders interpret analytics outputs in real settings, particularly when data conflict with professional judgment or athlete-reported experience. Greater attention is also needed to ethical and translational questions, including privacy, consent, bias, explainability, data ownership, athlete surveillance, and accountability in algorithm-supported decisions. Future studies may also test, refine, or extend the responsible and integrative framework proposed in this study across different sport levels, including elite sport, university sport, youth sport, para-sport, women's sport, and resource-limited sport systems. This would help determine whether sports analytics can mature not only as a technically advanced field, but also as a responsible, interpretable, and athlete-centred mode of applied sport science.

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### **CONFLICT OF INTEREST**

The author declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

### **AI USE DISCLOSURE**

In accordance with current publishing ethics and transparency recommendations, generative artificial intelligence tools (ChatGPT 5.3, OpenAI) were used to assist in language refinement, structural organization, and editing of the manuscript. All intellectual content, analysis, interpretation of results, and final decisions remain the sole responsibility of the author.

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