

Special Issue: Sports Performance: Data Measurement, Analysis and Improvement

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1. Introduction

The systematic measurement and analysis of sports performance has profoundly transformed over the past three decades. What began as relatively simple notational analysis and aggregate match statistics has evolved into an ecosystem of continuous monitoring, high-resolution tracking, and data-intensive modelling that permeates training and competition environments. This evolution has been driven by several converging factors [1,2].

First, rapid advances in sensor and tracking technologies—including GPS and local positioning systems, inertial measurement units, instrumented equipment, and computer-vision-based optical tracking—have enabled the large-scale capture of detailed external-load and positional data. These systems now routinely quantify distances covered at different intensities, accelerations, and decelerations; changes in direction; high-speed efforts; and spatiotemporal tactical structures in team sports, with sufficient validity and reliability for high-performance environments. Advances in wearable and physiological monitoring tools have facilitated the parallel assessment of internal load and readiness, including heart rate, heart rate variability, metabolic cost, body composition, and neuromuscular status [3–5].

Second, the emergence of big data and advanced analytics has changed how these measurements are interpreted. Techniques such as generalised linear models, mixed-effects models, machine learning, and, more recently, deep learning, have been progressively incorporated into sports science to model the complex, nonlinear relationships among performance, load, and contextual variables. In football, for example, event and tracking data have led to the creation a series of advanced metrics—expected goals (xGs), expected threat (xT), action-valuing models such as VAEF, and sophisticated plus-minus and rating systems, which seek to attribute value to individual actions and players within the collective game context. Similar trends can be observed in other sports, where integrated performance indicators combining physical, technical, and tactical information are increasingly used for decision support [6–8].

Third, emphasis has been growing on translational and practitioner-oriented research. Several editorials and reviews have highlighted the need to bridge the gap between laboratory-based experimentation and field reality, advocating for applied research models that start from practical questions, use ecologically valid designs, and deliver outputs that can be directly embedded into coaching and performance processes. In parallel, the concept of precision sports science has gained traction: the idea that data and analytics should support individualised load management, injury risk mitigation, and performance



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optimisation rather than applying uniform prescriptions across heterogeneous athletes and contexts [9–11].

Within this broader landscape, persistent challenges remain. One prominent issue is the lack of standardisation in certain measurement domains, particularly in women's and youth sports. For example, recent syntheses of tracking research in female team sports have documented substantial heterogeneity in the speed thresholds used to define high-speed running and sprinting, with clear implications for the interpretation and comparison of external load across studies and practices. Another challenge lies in reconciling the increasing complexity of analytical models with the need for interpretability, uncertainty quantification, and ethical governance—especially when predictions inform high-stakes decisions about selection, contracts, or talent identification.

This Special Issue “Sports Performance: Data Measurement, Analysis and Improvement” was conceived against this backdrop. Its aim was to assemble empirical and methodological contributions that

- (1) Propose and validate new tools and indicators for measuring performance and load in ecologically valid settings.
- (2) Apply advanced analytic approaches—including machine learning, complex modelling and integrative frameworks—to extract meaningful structure from rich performance datasets.
- (3) Demonstrate practical applications in training design, competition analysis and strategic decision-making, with clear implications for practitioners and organisations.

The sixteen articles published in this Special Issue cover a broad spectrum of sports (football, basketball, handball, swimming, artistic gymnastics, CrossFit, alpine skiing, and women's team sports more generally) and competitive levels, from youth and non-professional environments to elite international competitions. Collectively, the articles illustrate how measurement and analytics can be integrated to support performance enhancement and athlete health across diverse contexts.

2. An Overview of Published Articles

Although the contributions are diverse, they can be grouped into three broad thematic clusters: (i) performance analytics and decision support in team sports, with a particular emphasis on football; (ii) monitoring of external and internal load, body composition, and contextual factors in team sports; and (iii) physiological, biomechanical, and training-focused studies in individual and mixed sports.

2.1. Performance Analytics and Decision Support in Team Sports

Several articles focus on football analytics, demonstrating how detailed event and tracking data can inform tactical evaluation and strategic decisions. Experimental work on penalty kicking explores the trade-off between ball speed and accuracy when targeting different goal areas, with practical implications for penalty strategy under pressure. Models that extend or refine existing frameworks such as the chain on goals or expected threat integrate multiple metrics (e.g., possession value, xGs, xGOT, off-ball positioning) to generate more realistic and context-sensitive estimates of attacking and defensive value, thereby enriching the toolkit available to analysts and coaches.

At a more strategic level, explainable machine learning models are deployed to forecast the future quality and market value of professional football players, incorporating uncertainty estimates that are crucial for high-risk transfer decisions. Complementary work using tracking data from the FIFA World Cup examines how the five-substitution rule affects team running performance, showing that increased use of substitutions is associated

with greater total distance and sprinting activity and underlining the role of substitution strategies as a lever for load management in modern elite football.

Two further contributions adopt a broader organisational and technological perspective. A survey-based study of sports science and medicine resources in English non-league football documents considerable variability in access to facilities, testing practices, performance analysis, and medical and nutritional support, emphasising the structural constraints faced by clubs below the fully professional tier. In parallel, a comparative analysis of blockchain applications in football and basketball examines how this emerging technology is being used for ticketing, fan engagement, performance analytics, and financial mechanisms, highlighting sport-specific patterns of adoption and perceived benefits.

2.2. Load Monitoring, Body Composition, and Contextual Influences in Team Sports

A second group of articles focuses on external load monitoring, body composition, and context in team sports, with a strong representation of women's and youth sports. A systematic review synthesises the evidence on high-speed running and sprinting thresholds in elite female team sports, revealing substantial heterogeneity in the absolute speed cut-offs used across sports and studies and advocating for sport- and sex-specific approaches to threshold definition. The work provides a valuable reference for practitioners seeking to interpret tracking data and design drills that ensure adequate high-speed exposure for female athletes.

Two empirical studies in basketball address different facets of performance. One investigates the relationship between body composition and physical performance in professional players by sex, showing that higher fat-free mass and lower body fat are strongly associated with better jump, strength, and sprint outcomes, and that male players, on average, present more favourable body compositions and higher performance levels than their female counterparts. Another analyses home court advantage and home win percentage in women's professional basketball across multiple leagues and continents, finding meaningful geographical variation and identifying travel, regional characteristics, and fan attendance as key contextual determinants of home advantage.

Beyond basketball, a study of male handball examines how anthropometric variables, chronological age, and training age relate to speed, agility, and explosive power, underscoring the importance of considering growth and training history alongside body size when evaluating and developing players. Together, these articles reinforce the idea that performance in team sports is shaped not only by raw physical attributes but also by contextual and developmental factors that must be accounted for when interpreting data and planning training.

2.3. Physiological, Biomechanical and Training Studies in Individual and Mixed Sports

The third cluster encompasses individual and mixed sports, where detailed physiological and biomechanical assessments are used to guide training and competition strategies. In swimming, one study analyses interval speed characteristics and pacing strategies in high-level 100 m backstroke, showing that elite swimmers of both sexes differentiate themselves from sub-elite athletes through higher speeds in key race segments (starts, turns, final sprint) and distinct pacing patterns. A complementary case study of an elite 1500 m swimmer integrates repeated measurements of resting metabolic rate, body composition and nutritional intake over a macrocycle, illustrating how closely aligned fuelling strategies and measured energy expenditure can support preparation for major competitions.

In the domain of high-intensity functional training, an exploratory analysis of the CrossFit benchmark workout "Fran" examines how ventilatory responses, oxygen uptake, neuromuscular performance and lactate accumulation relate to completion time,

and how these relationships differ by sex and training experience. The findings suggest subgroup-specific performance profiles, supporting more tailored training prescriptions in this increasingly popular modality.

Two further studies focus on youth athletes in technically demanding sports. In artistic gymnastics, research on young female gymnasts shows that body cell mass and muscle strength are positively associated with training hours per session, even after adjusting for potential confounders, highlighting the importance of session structure and intensity in early specialisation contexts. In alpine skiing, a 10-week complex dry-land balance programme combining neuromuscular, plyometric, core, proprioceptive and equipment-based exercises produces improvements in static balance and several on-snow performance metrics, as measured by wearable technology, underlining the potential of balance-focused interventions and digital feedback tools for technical skill development in youth skiers.

3. Conclusions

The contributions gathered in this Special Issue confirm that measurement, analysis and performance improvement are inseparable dimensions of contemporary sports science. Accurate, context-aware measurement provides the raw material for meaningful analyses; advanced analytical methods transform these data into interpretable insights; and carefully designed interventions and decision processes are required to translate those insights into tangible performance gains.

Three overarching conclusions emerge from the body of work presented here:

1. Contextualised and standardised measurement remains a priority.

Across sports and populations, the articles highlight both the capabilities of and the current gaps in measurement systems. The lack of consensus on speed thresholds in female team sports; the nuanced relationships between anthropometrics, age and motor performance; and the differential resource landscapes between professional and non-professional environments all point to the need for measurement frameworks that are sport-, sex-, age- and level-specific, while also striving for enough standardisation to allow comparison and synthesis.

2. Analytics must be both sophisticated and actionable.

Work on refined threat models, chain-based performance evaluation, forecasting of player quality and value, and the analysis of substitution effects demonstrates the potential of advanced modelling to provide competitive advantages in recruitment, tactical planning and load management. However, these same studies emphasise interpretability, uncertainty quantification and practitioner orientation as essential criteria for real-world adoption. Models that cannot be understood or trusted by coaches and decision-makers are unlikely to influence practice, regardless of their theoretical performance.

3. Performance optimisation is intertwined with health, development and ethics.

Studies on pacing strategies, metabolic and nutritional management, balance and strength development in youth athletes, and body composition–performance relationships underline the importance of aligning performance goals with athlete health and long-term development pathways. At the same time, the increasing reliance on data and predictive models—together with emerging technologies such as blockchain—raises questions about data governance, fairness and responsible use, which will require ongoing attention from researchers, practitioners and governing bodies.

Overall, this Special Issue demonstrates that data measurement, analysis and improvement in sports performance is now a mature but rapidly evolving field, characterised by methodological sophistication, increasing cross-disciplinary integration and a growing

emphasis on practical impact. We hope that the work presented here will not only enrich the scientific literature but also serve as a catalyst for new collaborations and innovations that continue to refine how performance is measured, understood and optimised in sport.

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References

1. Cullinane, A.; Davies, G.; O'Donoghue, P. *An Introduction to Performance Analysis of Sport*; Routledge: London, UK, 2024; ISBN 9781003375463.
2. Ferraz, A.; Duarte-Mendes, P.; Sarmiento, H.; Valente-Dos-Santos, J.; Travassos, B. Tracking Devices and Physical Performance Analysis in Team Sports: A Comprehensive Framework for Research—Trends and Future Directions. *Front. Sports Act. Living* **2023**, *5*, 1284086. [[CrossRef](#)] [[PubMed](#)]
3. Fury, M.S.; Oh, L.S.; Berkson, E.M. New Opportunities in Assessing Return to Performance in the Elite Athlete: Unifying Sports Medicine, Data Analytics, and Sports Science. *Arthrosc. Sports Med. Rehabil.* **2022**, *4*, e1897–e1902. [[CrossRef](#)] [[PubMed](#)]
4. Jia, Y.; Anida Abdullah, N.; Eliza, H.; Lu, Q.; Si, D.; Guo, H.; Wang, W. A Narrative Review of Deep Learning Applications in Sports Performance Analysis: Current Practices, Challenges, and Future Directions. *BMC Sports Sci. Med. Rehabil.* **2025**, *17*, 249. [[CrossRef](#)] [[PubMed](#)]
5. Meyer, F.; Sandbakk, Ø.; Millet, G.P. Editorial: Sport Performance Analysis: From the Laboratory to the Field. *Front. Sports Act. Living* **2024**, *6*, 1372080. [[CrossRef](#)] [[PubMed](#)]
6. Bai, Z.; Bai, X. Sports Big Data: Management, Analysis, Applications, and Challenges. *Complexity* **2021**, *2021*, 6676297. [[CrossRef](#)]
7. Morgulev, E.; Azar, O.H.; Lidor, R. Sports Analytics and the Big-Data Era. *Int. J. Data Sci. Anal.* **2018**, *5*, 213–222. [[CrossRef](#)]
8. Watanabe, N.M.; Shapiro, S.; Drayer, J. Big Data and Analytics in Sport Management. *J. Sport Manag.* **2021**, *35*, 197–202. [[CrossRef](#)]
9. Smith, B.; Williams, O.; Bone, L.; The Moving Social Work Co-Production Collective. Co-Production: A Resource to Guide Co-Producing Research in the Sport, Exercise, and Health Sciences. *Qual. Res. Sport Exerc. Health* **2023**, *15*, 159–187. [[CrossRef](#)]
10. Close, G.L.; Kasper, A.M.; Morton, J.P. From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research. *Sports Med.* **2019**, *49*, 25–37. [[CrossRef](#)] [[PubMed](#)]
11. Fullagar, H.H.K.; McCall, A.; Impellizzeri, F.M.; Favero, T.; Coutts, A.J. The Translation of Sport Science Research to the Field: A Current Opinion and Overview on the Perceptions of Practitioners, Researchers and Coaches. *Sports Med.* **2019**, *49*, 1817–1824. [[CrossRef](#)] [[PubMed](#)]

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