

# Data-Driven Dynamics in Soccer: Exploring the Impact of Data Analytics on Strategy and Fan Engagement

**KAI XI CHEW**

*STANFORD UNIVERSITY*

Motivated by a deep passion for soccer and a keen interest in computer science, I initiated this research to address two profound yet overlooked aspects of data analytics in soccer: first, the impact of data analytics on tactical strategy, and second, the need to explore how fan culture is intricately tied to data analytics in the sport. My paper thus investigates how data from technologies like GPS devices are not only utilized in soccer to enhance player performance and decision-making, but also to drive fan engagement. This research was conducted through a thorough review of academic journals, books, and case studies to analyze how clubs, notably FC Barcelona, implement GPS technology in soccer and its resultant effects on player performance. Additionally, the research involved examining scholarly articles and reports on fan engagement and data analytics in sports to understand the broader implications of these technologies in soccer. The paper also drew on insights from books and articles discussing the ethical aspects of sports analytics to provide a well-rounded view of the topic. Overall, this paper concludes that data analytics reshapes soccer strategy and fan engagement, but emphasizes the need to balance technology with the sport's traditional spirit and address ethical considerations in data utilization.

**Keywords:** Data Analytics, Soccer, Culture, Technology, Fan Engagement, Soccer Analytics, GPS technology, Data-Driven Decision Making, Sports Performance Analysis, Sport Technology Ethics, Data Privacy in Sports, Cultural Impact of Sports Technology, Fan Engagement Strategies

**DOI:** <https://doi.org/10.60690/9gp3xd71>

## Introduction

This story of innovation begins with the integration of advanced Global Positioning System (GPS) devices into the training and match-day routines of soccer players. These devices, small yet powerful, are designed to capture every sprint, every movement, and even the slightest change in direction or speed. Imagine a scene at FC Barcelona's Camp Nou, the iconic stadium buzzing with excitement. On the field, a player like Sergio Busquets, known for his tactical intelligence, is in action. But now, there is an added layer to his game. The GPS device snugly fitted in his vest is silently collecting data – data that speaks volumes about his endurance and tactical movements. This moment perfectly illustrates how FC Barcelona harnesses the power of precise data to enhance their game. During the 2021-22 LaLiga season, it was this very technology that highlighted Busquets' remarkable stamina, showcasing an average distance of about 11.19 km covered per game, a testament to his relentless energy and strategic positioning. In another electrifying instance, during the 2022 Champions League, Ousmane Dembélé, known for his blistering pace, dashes across the field. The crowd roars as the GPS device clocks his peak speed at an astounding 36.60 km/h. This is not

merely about speed; it is about quantifying the unquantifiable, turning a display of athletic prowess into a data point that can be analyzed and appreciated. It is about transforming raw data into actionable insights.

These examples showcase a broader trend: the profound impact of data analysis across varied fields. While the realm of soccer demonstrates vividly the positive aspects of this impact, an entirely different context where its effects are equally as striking, albeit in a more concerning light, is in the field of sociopolitical policy, explored by Susan Greenhalgh in *Just One Child: Science and Policy In Deng's China*. Greenhalgh reveals how China's once-celebrated large population, when compared with data from industrialized nations, transformed into a symbol of national struggle. She states, "Once a cause for pride, China's bulky population was now a source of national humiliation" (Greenhalgh 118). This shift, driven by data, underscores a cautionary tale: the potential for misrepresentation or overreliance on quantified data, leading decision-makers astray. Greenhalgh's analysis serves as a reminder of the double-edged nature of data in shaping policies and public perception. Similarly, in soccer, while the meticulous analysis of player data like stamina, speed, and

distance covered offers significant tactical advantages, it also carries a latent warning.

Overreliance on quantitative data could potentially overshadow other crucial aspects of the game, such as player intuition, teamwork, and mental resilience. This reliance on data, if not balanced with qualitative judgment, risks reducing the complex dynamics of soccer to mere numbers. Thus, the transformative power of data in sports, just as in policy, requires a careful balance to avoid leading decision-makers, coaches, and fans down a path where the essence of the sport is lost in the digits.

First delving into the integration and influence of GPS technology in soccer analytics, focusing on its origins, development, and operational use in the sport, the paper then utilizes a case study of FC Barcelona to highlight the application of GPS data in training and tactical decisions, and its impact on player performance. The scope then broadens to assess how various soccer teams utilize GPS technology, exploring its diverse applications and effects on fan engagement, both in-stadium and digitally. The paper also addresses the challenges and ethical concerns of soccer analytics, including data privacy and the balance between data-driven and intuitive approaches, emphasizing their impact on the sport's culture and fan experience. In essence, this paper aims to shift the focus in soccer analytics from solely examining the technology's role in isolation to exploring the cultural and historical context that has enabled its profound impact on the sport. I argue that the effectiveness of advanced technologies like GPS in transforming soccer's strategic and training methodologies would have been considerably less pronounced without the cultural and historical backdrop that nurtured their adoption.

## Advent of GPS Technology in Soccer

Since its introduction in 2008, GPS technology in soccer has undergone a significant evolution and is now an indispensable tool for soccer analytics. Initially, it was integrated into Electronic Performance and Tracking Systems (EPTS) to monitor basic metrics like running speed, distance covered, and heart rate. This initial use marked the start of a technological revolution in measuring and analyzing player performance and fitness. With the technology's maturity, GPS devices began to offer more nuanced metrics such as acceleration, deceleration, and player workload, signaling a shift from mere physical monitoring to a more comprehensive performance analysis. This advancement facilitated a deeper understanding of the physical demands placed on players during games and training sessions. Furthermore, the application of GPS technology extended beyond physical metrics to include strategic analysis. Coaches and analysts started using GPS data to scrutinize players' positioning and space utilization on the field. This strategic application provided valuable insights for tactical planning, allowing teams to develop strategies based on precise movement patterns and the physical capabilities of players. Tracking a player's movement in relation to teammates and opponents opened new avenues for tactical innovation and in-game decision-making.

This progression from basic tracking to advanced performance analysis necessitated not only technological innovation but also developmental and operational excellence in the implementation of these systems. In developmental terms,

miniaturization and enhanced wearability were crucial. GPS devices evolved into compact, lightweight units that can be worn without hindrance, enabling more natural movement and accurate data collection. Paired with advancements in battery life and durability, the devices became capable of enduring the rigors of a full match or extended training sessions while providing uninterrupted data.

Operationally, the emphasis has shifted toward efficient data synchronization and analysis. Integrating data from multiple players into a cohesive analytical framework became vital for team-level insights, demanding sophisticated software solutions that could process complex GPS data and present it in an actionable format for coaches and players. Features like customizable dashboards and detailed reporting tools enabled teams to tailor strategies based on comprehensive data analysis. GPS technology's operational use also encompasses training load management and injury prevention. By monitoring various physical parameters, coaches can fine-tune training regimens to optimize performance while minimizing injury risks. The development of GPS technology has continued in response to these operational needs, emphasizing scalability and integration. Modern GPS systems are designed to be adaptable to the infrastructures of diverse teams, ensuring that teams of varying sizes and resources can access the benefits of advanced sports analytics.

## FC Barcelona's Use of GPS Technology in Soccer

FC Barcelona's implementation of the WIMU PRO GPS system across its youth and senior teams exemplifies their leadership in sports science. This sophisticated system tracks and analyzes key variables such as high metabolic load distance, high-speed running, player load, and total distance. The WIMU system, integrated into comfortable GPS vests, is a comprehensive solution for athlete performance monitoring, capable of generating up to 20,000 data points per second across over 250 variables. The data is processed using the ETPS performance electronic tracking device and advanced calculus programs. The WIMU PRO system offers features like real-time data visualization, in-depth post-session analysis, and cloud-based dashboards, enhancing the club's ability to optimize training, manage player fitness, and prevent injuries. The system's flexibility for use in various conditions, combined with its comprehensive data collection, makes it a vital tool for FC Barcelona in maintaining athlete health and improving performance on the field.

In the 2017/2018 season, a detailed study at FC Barcelona, utilizing the WIMU PRO GPS system, analyzed the activities of their first male team, U18, and U19 teams over a considerable period. This comprehensive research covered 46 weeks for the first team, 45 weeks for the U18 team, and 44 weeks for the U19 team, involving numerous training sessions and official matches. The GPS data revealed that load distributions, indicative of the physical stress experienced by players, were significantly higher on game days and during training sessions three days prior to matches, underlining the deliberate planning of training intensity to ensure players are optimally prepared for upcoming games. Additionally, the study found that muscle injuries, both time-loss

(injuries severe enough to necessitate a break from training) and non-time-loss (less severe injuries that do not prevent continued participation in sports activities), were closely related to these load distributions. The data showed 34 muscle injuries across the teams, with the highest injury rates recorded on game days, followed by those critical training sessions before matches. This correlation suggests a direct link between the intensity of external workload and the likelihood of muscle injuries. Notably, the GPS metrics indicated that the incidence of injuries was higher in training sessions three days prior to the match than on the match day itself, contrary to what might be expected from merely analyzing exposure hours (number of hours players spend engaged in activities where they are at risk of injury). This nuanced understanding emphasizes the importance of carefully managing training loads to optimize player health and performance, and the use of the WIMO PRO system by FC Barcelona allowed for such a precise and data-driven approach to monitoring and adjusting training regimens.

While the case study highlights the potential of GPS systems in transforming sports training and player management, it also brings to light the limitations of such technologies. One key issue is the resource-intensive nature of such systems. The need for sophisticated software and skilled analysts to process and interpret the massive amount of data generated can create a significant barrier for smaller organizations or teams with limited budgets. This disparity in resources can potentially lead to a widening gap in performance analytics capabilities between wealthier, more technologically advanced clubs and their less affluent counterparts, affecting the competitive balance within the sport. Another notable concern is the potential over-reliance or dependency on these technologies by players and coaching staff, which poses practical risks. For instance, if a team becomes too dependent on data for decision-making, they may find themselves at a disadvantage during situations where the technology is unavailable due to technical issues or other reasons. This dependency also raises questions about player autonomy and the potential for data to dictate every aspect of training and play. While data-driven approaches can optimize performance, they might also lead to scenarios where players are treated more as assets to be managed through numbers rather than as individuals with unique skills and instincts.

## Applications of GPS Technology in Soccer Among Other Teams

Various other soccer teams employ GPS technology with distinct applications and objectives, shaped by the capabilities of different brands. For instance, Premier League teams like Arsenal, Manchester City, and Sunderland use STATSports' Viper pods to monitor players' physiological performance and tailor training workloads. This technology, similar to FC Barcelona's WIMO PRO system, aids in injury prevention by tracking metrics such as high-speed running and acceleration. On the other hand, European giants like Bayern Munich FC and Paris Saint Germain FC utilize Catapult's GPS Vest Tracker, known for its comfort and detailed performance analysis, including heat maps for visual tracking. AC Milan and AS Monaco have adopted GPEXE by Exilio for its high-frequency devices, offering precision in tracking speed and directional changes. Meanwhile, Playermaker, used by

teams like Liverpool FC, offers a unique approach with wearable devices for cleats, focusing on physical and technical data like kick velocity. These varied applications underscore how different GPS technologies cater to the specific needs of soccer teams, enhancing training, performance analysis, and injury prevention strategies.

## Influence of Data Analytics on Fan Culture in Soccer

The UEFA Champions League Data API (Application Programming Interface) is a pivotal tool that has revolutionized how fans engage with soccer. It serves as a crucial gateway, providing real-time data, including GPS data, that greatly enhances the viewing experience. In fact, recent studies conducted by Data Sports Group have demonstrated a significant increase in fan engagement and satisfaction due to these real-time data features. Through this API, fans gain instant access to live scores, detailed player statistics, and team line-ups as the game unfolds. This means fans are no longer just passive spectators; they are empowered to analyze the game with the same depth of data available to commentators and analysts. The crucial link to fan-facing platforms comes into play here: this rich, real-time data from the API is seamlessly integrated into various fan-centric digital services and applications. These platforms utilize the API's data to offer personalized fan experiences, including tailored match notifications, player-specific highlights, and curated video content. This integration ensures that fans are constantly engaged with relevant and up-to-date information about their favorite teams and players, connecting them intimately to every pivotal moment of the games they are most passionate about. Moreover, the technology facilitates greater fan involvement with their favorite teams, both during and after events. For instance, through digital platforms, fans can participate in activities like voting on logo designs, staying updated with team news, and providing feedback on significant team decisions, such as selecting new managers, through polls and other interactive tools. Innovative engagement strategies extend to interactive fan experiences in the stadium, where fans can enjoy in-game features like selecting a song or receiving rewards for frequent concession visits. Data analytics enables more precise targeting of fans, offering them personalized promotions and discounts based on their past attendance and preferences. Such access enables a more interactive and informed viewing experience, fostering deeper connections between fans and their favorite teams or players, and enriching the overall fan culture in soccer. Besides real-time data, the Champions League Data API also offers extensive historical data, enabling fans to explore the tournament's rich history. This includes past results, team performances, and individual player records. Such data allows fans to relive memorable moments and gain a broader perspective on the evolution of the Champions League tournament.

Beyond that, the integration of VR (Virtual Reality) with the UEFA Champions League Data API has revolutionized the way fans consume soccer. In the 2017 UEFA Champions League semi-finals and final, UEFA introduced a groundbreaking virtual reality (VR) experience, revolutionizing the way fans interacted with football. Central to this innovation was the virtual VIP lounge, accessible via Samsung Gear VR, Oculus glasses, and mobile phones, creating an immersive, interactive environment

that went beyond traditional viewing. The experience featured a live stream view, offering fans a unique perspective of the game directly from the pitch. This view was enhanced with 180-degree live streaming and the ability to teleport around the pitch for various 360-degree viewpoints, allowing fans to virtually jump to different locations and gain a comprehensive view of the game. Another significant aspect was the dashboard view, which provided a wealth of live statistics, video replays, lineups, and exclusive 360-degree videos. This feature enabled fans to delve deeper into the game, offering insights into player performances, game statistics, and replays from different angles. The inclusion of exclusive 360-degree videos, such as behind-the-scenes footage and player interviews, further enriched the fan experience, offering insights and content usually inaccessible to viewers.

In the realm of fantasy football and betting, the availability of data through APIs has significantly transformed how fans interact with the sport. These APIs provide access to real-time odds, player pricing, and comprehensive player and team statistics, empowering fans to make informed, data-driven decisions when managing their fantasy teams or engaging in sports betting. This high level of integration means that every player change, injury update, or real-world performance can directly impact both the outcomes in fantasy leagues and the betting markets, making the experience much more dynamic and interactive. Moreover, this integration has elevated the strategic aspect of both fantasy football and betting. Fans now have the ability to analyze vast amounts of data, from player performance metrics to historical trends, allowing for more nuanced and informed decision-making. This has led to a more competitive environment in both realms, where success is not just about luck or superficial knowledge of the sport, but also about the ability to interpret and utilize data effectively. The availability of detailed data has also fostered a deeper connection between fans, the sport, and the betting aspects. By engaging with the data, fans become active participants, gaining a deeper understanding of the sport's nuances, player capabilities, and team strategies. This enhances their overall experience as spectators and bettors, leading to a more immersive experience where fans are more invested in both the real-world games, their fantasy league performances, and their betting strategies. Furthermore, this technology-driven approach has opened up new avenues for community engagement and social interaction. Online platforms and forums where fans discuss strategies, share insights, and celebrate victories have become integral to both the fantasy football and betting cultures. These communities foster a sense of belonging and camaraderie among fans, transcending geographical barriers and bringing together people with a shared passion for the sport and betting.

### Implications of Data Analytics in Soccer

The evolution of data analytics in soccer not only transforms the way the game is played but also challenges its traditional ethos, which has long emphasized the natural, intuitive aspects of the sport. Historically, soccer has been celebrated for its spontaneity, the natural flair of its players, and a certain unpredictability that comes with human decision-making. However, the rise of data-driven methods potentially disrupts this, as decisions increasingly rely on statistical analysis and predictive modeling. This shift could diminish the emphasis on instinctive play and the

artistic charm that has been a hallmark of soccer. In the pursuit of analytical excellence, there is a risk that soccer might lose some of its traditional essence, which was less about numbers and more about human spontaneity and creativity. Jennifer Robertson in *Robo Sapiens Japanicus* observes a similar phenomenon in another domain: "In short, roboticists tend uncritically to reproduce and reinforce dominant stereotypes (or archetypes) attached to human female and male bodies" (Robertson 100). This reflection is pertinent in soccer analytics, as the reliance on data might lead to a homogenization of playing styles, echoing the way technology can sometimes perpetuate existing norms or biases in other fields. In soccer, one such bias could be in player recruitment and selection, where data analytics might disproportionately favor players with certain physical attributes, such as height or speed, over those with exceptional strategic thinking or technical skills. This trend could inadvertently uphold a bias towards selecting physically dominant players, potentially overlooking talented individuals who do not fit this specific mold. Additionally, data analysis might also reinforce tactical norms, encouraging teams to adopt similar styles of play based on what is statistically successful, thus stifling tactical diversity and innovation. As teams increasingly adopt strategies based on similar analytical insights, the creative unpredictability that has long been a hallmark of the game might also dampen. Moreover, the increasing prominence of data analytics in soccer raises questions about the sport's cultural legacy and its connection with fans. Traditionalists argue that the essence of soccer lies in its unpredictability and the emotional connection it fosters among fans, aspects that might be diluted if the game becomes overly analytical. The charm of witnessing a moment of individual brilliance or a tactical masterstroke born out of instinct rather than data-driven planning is a crucial part of soccer's allure. There is a growing concern that an over-reliance on analytics could lead to a disconnect with fans who cherish these spontaneous aspects of the game, similar to how technology, as highlighted by Robertson, might influence societal perceptions in ways that are not always anticipated or desired.

Moreover, the integration of advanced data analytics in soccer brings to the forefront a range of ethical considerations, particularly concerning data surveillance and privacy. The extensive collection and meticulous analysis of player data, while beneficial for performance enhancement and strategic planning, engender scenarios of asymmetric information. In such situations, management and coaching staff may have access to significantly more information about players' physical and mental states than is shared with the players themselves. This imbalance can lead to potential conflicts and ethical dilemmas in areas such as contract negotiations, where management might use detailed data insights to leverage terms, or in player evaluations, where decisions could be made based on data that players are not privy to or fully understand. This disparity in information also raises concerns about the overall transparency and fairness within the sport. Players, as the primary subjects of this data collection, might feel commodified or under constant scrutiny, affecting their mental well-being and their relationships with management and coaching staff. The lack of transparent policies regarding data collection and usage can create an environment of mistrust and unease. In addition to these concerns, the utilization of personal and biometric data in soccer introduces significant privacy issues.

Questions arise about the extent to which this data should be collected, analyzed, and utilized. There are ongoing debates about the ownership of such data - whether it belongs to the players, the teams, or the leagues - and about who should have access to it. The potential for misuse of sensitive personal data is a legitimate concern, especially in an era where data breaches and privacy violations are increasingly common.

## Conclusion

This paper transcends the boundaries of soccer, offering insights with far-reaching implications in the broader context of sports analytics, cultural dynamics, and technological ethics. Dissecting the role of data analytics in soccer not only sheds light on the sport's tactical evolution but also serves as a microcosm for understanding the impact of technology in modern sports. The findings highlight a paradigm shift in athletic performance analysis and strategy formulation, reflecting a broader trend in the sports world where data-driven decision-making is becoming increasingly paramount. Furthermore, the interweaving of data analytics with soccer's cultural aspects exemplifies how modern technology can influence and redefine cultural practices and communal experiences. Here, Bruno Latour's insight in *We Have Never Been Modern* is particularly relevant. Latour observes, "So long as we consider these two practices of translation and purification separately, we are truly modern - that is, we willingly subscribe to the critical project even though that project is developed only through the proliferation of hybrids down below" (Latour 11). This quote underscores the intertwined processes of "purification" and "hybridization" in modernity. In the context of soccer, data analytics represents a form of purification, dissecting the sport into quantifiable metrics. However, its integration within the cultural fabric of soccer exemplifies hybridization. This interplay between the scientific rigor of data analysis and its assimilation into the cultural realm of soccer embodies Latour's concept of co-production, illustrating the complex, intertwined nature of technological advancements and cultural evolution. Through this lens, the evolution of soccer with data analytics is not just a scientific development but a cultural transformation, showcasing the inseparable nature of science and culture as outlined by Latour.

From an ethical standpoint, the exploration of privacy and surveillance in soccer analytics resonates far beyond the boundaries of the sport, touching on pivotal concerns in the era of big data. The paper uncovers challenges and dilemmas that, while rooted in soccer, are reflective of broader societal questions concerning data privacy, the ethical use of personal information, and the delicate equilibrium between technological progress and individual rights. The paper does more than just bridge the specific issues within soccer analytics to larger ethical considerations; it offers a significant contribution to the dialogue on responsibly navigating technological innovation. Moreover, the implications of this research extend well beyond the soccer field, emphasizing its crucial role in the broader discourse on technology's place in society. It compels us to critically examine the integration and regulation of technological advancements, extending our inquiry beyond the realm of sports to various facets of life. In doing so, the insights gleaned from soccer become invaluable for policymakers, technologists, and cultural analysts,

highlighting the crucial need for a harmonious balance where technology enhances, rather than dominates, the human and cultural elements of our society.

## References

- [1] Greenhalgh, S. (2008). *Just one child: Science and policy in Deng's China*. University of California Press. <https://www.amazon.com/Just-One-Child-Science-Policy/dp/0520253396>
- [2] Robertson, J. (2018). *Robo Sapiens Japanicus: Robots, gender, family, and the Japanese nation*. University of California Press. <https://www.amazon.com/Robo-sapiens-japanicus-Robots-Japanes/dp/0520283201>
- [3] Latour, B. (1993). *We Have Never Been Modern*. Harvard University Press. <https://www.amazon.com/We-Have-Never-Been-Modern/dp/0674948394>
- [4] Alamar, B. C. (2013). *Sports Analytics: A Guide for Coaches, Managers, and Other Decision Makers*. Columbia University Press. <https://www.amazon.com/Sports-Analytics-Coaches-Managers-Decision/dp/0231162928>
- [5] Anderson, C., & Sally, D. (2013). *The Numbers Game: Why Everything You Know About Soccer Is Wrong*. Penguin Books. <https://www.amazon.com/Numbers-Game-Everything-About-Soccer/dp/0143124560>
- [6] Kuper, S., & Szymanski, S. (2018). *Soccernomics*. Bold Type Books. <https://www.amazon.com/Soccernomics-England-Germany-Australia-Destined/dp/1568584814>
- [7] Schneier, B. (2016). *Data and Goliath: The Hidden Battles to Collect Your Data and Control Your World*. W. W. Norton & Company. <https://www.amazon.com/Data-Goliath-Battles-Collect-Control/dp/039335217X>
- [8] Mayer-Schönberger, V., & Cukier, K. (2014). *Big Data: A Revolution That Will Transform How We Live, Work, and Think*. Harper Business. <https://www.amazon.com/Big-Data-Revolution-Transform-Think/dp/0544227751>
- [9] Martin, K. (2022). *Ethics of Data and Analytics: Concepts and Cases*. Auerbach Publications. <https://www.amazon.com/Ethics-Data-Analytics-Concepts-Cases/dp/1032062932>
- [10] De Silva, V., Caine, M., Skinner, J., Dogan, S., Kondoz, A., Peter, T., Axtell, E., Birnie, M., & Smith, B. (2018). *Player Tracking Data Analytics as a Tool for Physical Performance Management in Football: A Case Study from Chelsea Football Club Academy*. Sports (Basel, Switzerland), 6(4), 130. <https://doi.org/10.3390/sports6040130>
- [11] Dellar, A., da Silva, C. D., Hill-Haas, S., Wong, delP., Natali, A. J., De Lima, J. R., Bara Filho, M. G., Marins, J. J., Garcia, E. S., & Chamari, K. (2012). *Heart rate monitoring in soccer: interest and limits during competitive match play and training, practical application*. Journal of Strength and Conditioning Research, 26(10), 2890–2906. <https://doi.org/10.1519/JSC.0b013e3182429ac7>
- [12] Webb, A., Cloutier, A., & Brouard, F. (2023). *Innovations in global sports brands management: The case of FC Barcelona's Barça Museum*. Managing Sport and Leisure. <https://doi.org/10.1080/23750472.2023.2200491>
- [13] Fakataulavelua, A., Lang, M., & Moulard, J. (2023). *Streaming the beautiful game: Exploring big tech's growing presence in the soccer industry*. Frontiers in Sports and Active Living, 5, 1156601. <https://www.frontiersin.org/articles/10.3389/fspor.2023.1156601>
- [14] Escamilla-Fajardo, P., Núñez-Pomar, J. M., Ratten, V., & Crespo, J. (2020). *Entrepreneurship and Innovation in Soccer: Web of Science*

*Bibliometric Analysis.* *Sustainability*, 12(11), 4499. MDPI AG. <http://dx.doi.org/10.3390/su12114499>

[15] Beiderbeck, D., Evans, N., Frevel, N., & Schmidt, S. L. (2023). *The impact of technology on the future of football – A global Delphi study*. *Technological Forecasting and Social Change*, 187, 122186. <https://doi.org/10.1016/j.techfore.2022.122186>

[16] Muhammad Talha, & Mishal Sohail. (2023). *Digital Coaching and Mental Skills Development in Sports: Harnessing the Power of Information Technology*. *Revista De Psicología Del Deporte (Journal of Sport Psychology)*, 32(3), 90–99. <https://www.rpd-online.com/index.php/rpd/article/view/1387>

[17] Guitart, M., Casals, M., Casamichana, D., Corte's, J., Valle, F. X., McCall, A., et al. (2022). *Use of GPS to measure external load and estimate the incidence of muscle injuries in men's football: A novel descriptive study*. *PLoS ONE*, 17(2), e0263494. <https://doi.org/10.1371/journal.pone.0263494>

[18] Barça Innovation Hub. (n.d.). *Use of GPS devices to track players' load*. <https://barcainnovationhub.fcbarcelona.com/blog/the-use-of-gps-devices-to-track-players-load/>

[19] Barça Innovation Hub. (n.d.). *Monitoring technologies for sports analysis*. <https://barcainnovationhub.fcbarcelona.com/blog/monitoring-technologies-for-sports-analysis/>

[20] Hudl. (n.d.). *WIMU: Advanced GPS and GNSS for sports performance*. <https://www.hudl.com/products/wimu>

[21] Sport Performance Analysis. (n.d.). *GPS in professional sports - Sports performance analysis*. <https://www.sportperformanceanalysis.com/article/gps-in-professional-sports>

[22] Electronic Specifier. (n.d.). *A journey through the history of football technology*. <https://www.electronicsspecifier.com/news/analysis/a-journey-through-the-history-of-football-technology>

[23] Fútbol Lab. (n.d.). *Improving the performance of players with GPS technology in football*. <https://www.futbollab.com/en/news/improving-the-performance-of-players-with-gps-technology-in-football>

[24] Catapult Sports. (n.d.). *GPS football technology: Changing the game*. <https://one.catapultsports.com/blog/gps-football-technology-changing-the-game/>

[25] Data Sports Group. (n.d.). *Demystifying the UEFA Champions League data API*. <https://datasportsgroup.com/news-article/130071/demystifying-the-uefa-champions-league-data-api>

[26] Full Sail University Hub. (n.d.). *The current and future impact of virtual reality on sports*. <https://hub.fullsail.edu/articles/the-current-and-future-impact-of-virtual-reality-on-sports/>

[27] Live Score API. (n.d.). *Reflecting on the UEFA Champions League season: How our football APIs delivered unrivaled insights*. <https://live-score-api.com/posts/238-reflecting-on-the-uefa-champions-league-season-how-our-football-apis-delivered-unrivaled-insights>

[28] SoccerTake. (n.d.). *Soccer analytics: How data is changing the game*. <https://www.soccertake.com/performance/soccer-analytics-how-data-is-changing-the-game>

[29] Deloitte. (n.d.). *Fan engagement analytics: Improving fan experiences*. <https://www2.deloitte.com/us/en/pages/consumer-business/articles/fan-engagement-analytics-improving-fan-experiences.html>

[30] Data Sports Group. (n.d.). *The power of data: Transforming the fan experience in sports*. <https://datasportsgroup.com/news-article/130070/the-power-of-data-transforming-the-fan-experience-in-sports/>

[31] SoccerNovo. (n.d.). *Soccer GPS tracker: How it works and why players need it*. <https://soccernovo.com/soccer-gps-tracker/>

[32] Sky Sports. (n.d.). *Statsports: The training technology used by Arsenal, Man City, Barcelona, and more*. <https://www.skysports.com/football/news/11095/10502787/statsports-the-training-technology-used-by-arsenal-man-city-barcelona-and-more>

[33] SimpliFaster. (n.d.). *Use of GPS technology in team sports*. <https://simplifaster.com/articles/use-gps-technology-team-sports/>

[34] Global Sport Matters. (2019, September 11). *GPS trackers help soccer teams train smarter*. <https://globalsportmatters.com/health/2019/09/11/gps-trackers-help-soccer-teams-train-smarter/>

[35] STATSports. (n.d.). *How a Premier League side uses GPS tracking to improve performance and minimise injury*. <https://pro.statsports.com/how-a-premier-league-side-uses-gps-tracking-to-improve-performance-and-minimise-injury/>

[36] Barça Innovation Hub. (n.d.). *Monitoring technologies for sports analysis*. <https://barcainnovationhub.fcbarcelona.com/blog/monitoring-technologies-for-sports-analysis/>

[37] Databricks. (2022, March 31). *Stadium analytics: Increasing sports fan engagement with data and AI*. <https://www.databricks.com/blog/2022/03/31/stadium-analytics-increasing-sports-fan-engagement-with-data-and-ai.html>

[38] SpeedsDB. (n.d.). *Barcelona players' top speeds*. <https://speedsdb.com/soccer/barcelona-players-top-speeds>

[39] Barça Innovation Hub. (n.d.). *The use of GPS devices to track players' load*. <https://elearning.barcainnovationhub.com/the-use-of-gps-devices-to-track-players-load/>

[40] Sports Business Journal. (2019, March 5). *FC Barcelona, Realtrack Systems wearable technology WIMU*. <https://www.sportsbusinessjournal.com/Daily/Issues/2019/03/05/Technology/fc-barcelona-realtrack-systems-wearable-technology-wimu.aspx>

[41] FC Barcelona. (n.d.). *WIMU: The device that tracks athlete data*. <https://www.fcbarcelona.com/en/news/1746453/wimu-the-device-that-tracks-athlete-data>

[42] Barça Innovation Hub. (n.d.). *Part I: The story behind the collaboration between WIMU and Barça*. <https://barcainnovationhub.fcbarcelona.com/blog/part-i-the-story-behind-the-collaboration-between-wimu-and-barca/>

[43] SpeedsDB. (n.d.). *Ousmane Dembélé top speed*. [https://speedsdb.com/ousmane-dembèle-top-speed/](https://speedsdb.com/ousmane-dembеле-top-speed/)

[44] Sport. (n.d.). *FC Barcelona captain Sergio Busquets covered the most distance in La Liga*. <https://www.sport.es/en/news/barca/fc-barcelona-captain-sergio-busquets-covered-the-most-distance-in-la-liga-14142072>

[45] World Football Index. (2023, February). *The impact of technology on performance in soccer*. <https://worldfootballindex.com/2023/02/the-impact-of-technology-on-performance-in-soccer/>

[46] TeamStats. (n.d.). *The impact of technology on soccer: VAR, goal-line technology*. <https://www.teamstats.net/blog/the-impact-of-technology-on-soccer-var-goal-line-technology>

[47] Sports Business Journal. (2022, August 17). *Digital scouting, data, metrics*. <https://www.sportsbusinessjournal.com/Daily/Issues/2022/08/17/Technology/digital-scouting-data-metrics.aspx>