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The Role of Data Analytics in Sports Performance

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ABSTRACT: The inclusion of within sports has fundamentally changed how coaches, teams, and players alike look to performance improvement. This essay discusses the revolutionizing sports performance analysis, shedding light on its influence on decision-making, player development, and strategic planning across different sporting fields. Big data analysis in sport entails the gathering, processing, and analysis of huge volumes of data produced from various sources, such as wearables, sensors, video, and statistical data. With the help of sophisticated algorithms and machine learning, this data is converted into actionable intelligence, offering useful information to enhance training regimens, improve tactical planning, and reduce the risk of injury.

Contributions of big data to sports performance analytics is its potential to offer an end-to-end vision of player behavior and performance dynamics. Through the examination of complex performance measures like movement patterns, biomechanics, and physiological markers, coaches and sports scientists are able to determine strengths, weaknesses, and areas for development at level of detail previously unimaginable.

In customized training programs specific to each athlete's needs and attributes. Using predictive modelling and real-time tracking, coaches can maximize training loads, avoid overtraining, and achieve optimal performance outcomes while reducing the risk of injury.

Through the examination of aggregate performance metrics and opponent patterns, coaches are able to craft game strategies, modify formations, and make tactical decisions during games with more accuracy and effectiveness. Furthermore, big data-based insights enable teams to respond to evolving game conditions and take advantage of opponents' weaknesses in real-time. But the possible gains in terms of performance improvement, competitive edge, and spectator interest far exceed these issues. Through the utilization of the power of data-driven insights, athletes and teams can realize their potential, attain peak performance, and remain on top in a more competitive sporting environment.

KEYWORDS: Big Data Analytics, Sports Performance, Athlete Development, Tactical Strategies, Predictive Modeling

I. INTRODUCTION

In the last few years, the application of big data analytics force within the world of sports performance. The intersection of cutting-edge technologies, including wearable sensors, video analysis software, and advanced algorithms, has facilitated sports organizations to collect, analyse, and develop actionable insights from enormous amounts of data. This paradigm shift in sports analytics has transformed how athletes train, coaches plan, and teams play. Traditionally, sports performance analysis was based on subjective judgement and anecdotal experience. The arrival of big data has brought with it a new era of data-driven decision making and evidence-based practice. Through the utilization of big data analytics, sports organizations can gain unparalleled insight into several dimensions of athlete performance, including biomechanics, physiological metrics, and tactical dynamics.

This paper seeks contributes to improving sports performance analytics. The paper will discuss how big data is captured, analysed, and used to achieve improved enhance tactical planning, and acquire a competitive advantage. Further, this paper will Analyse the challenges and opportunities that come with adopting big data in sports such as data privacy issues, technological constraints, and ethics.



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Overall, the integration of big data analytics represents a paradigm shift in how sports are analysed. By leveraging the vast array of data at their disposal, sports organizations can unlock new insights, drive innovation, and ultimately elevate the level of performance in the sporting arena.

II. LITERATURE REVIEW

In sports performance has attracted and industry professionals in the past few years. There is abundant literature examining diverse facets of the phenomenon, varying from the technical methods used to the practical solutions for athlete growth and team victory. Big data analytics in sport at its foundation involves the collection, processing, and analysis of large volumes of data from wide-ranging sources such as wearable equipment, tracking, video, have investigated the technical issues of dealing with such huge amounts of data, such as processing power, and algorithm scaling.

In terms of practical applications, numerous studies have examined how big data analytics can enhance athlete development and performance optimization. For instance, scientists have explored the application of machine learning algorithms to forecast injury risk factors from physiological measures, biomechanical parameters, and training loads. Correlations in the data, coaches and sports scientists can apply specific interventions to reduce injury risks and extend athletes' careers. Additionally, big data analytics has transformed the process of developing and applying tactical strategies in sports. Researchers have worked on data from games to identify the tendencies of opponents, make strategic decisions, and refine decision-making processes while playing. Through the application of predictive modelling and real-time analysis, coaches are able to make strategic decisions on formations, tactics, and substitutions, putting their teams in a position of superiority on the field or court. Aside from its impact on athlete performance and strategic planning.

Researchers have studied how data-driven insights can influence marketing strategy, ticket pricing decisions and sponsorship activations, thus making the fan experience better and generating revenue for the sports organization. Privacy issues, data security threats, and ethical concerns have become primary topics of discussion and criticism. Researchers have emphasized the importance of well-defined guidelines and regulations to oversee the collection, use, and dissemination of athlete data so that ethical practices are maintained and privacy rights are safeguarded. In summary. Through the application of big data analytics, sports organizations can derive valuable insights, enhance performance, and remain competitive in a fast-evolving world. That said, proper care should be exercised to address the ethical and privacy concerns of data-driven approaches so that the purity of the sport is maintained and the rights of athletes are protected.

III. THEORETICAL FRAMEWORK

The incorporation is guided by a number of theoretical frameworks from diverse disciplines, offering a conceptual basis for appreciating its mechanisms, implications, and possible outcomes. This section describes prominent theoretical perspectives sports performance analysis.

Information Processing Theory: Information processing theory, borrowed from cognitive psychology, holds that people perceive, encode, process, and retrieve information from their world to make decisions and carry out tasks. For sports performance analysis, big data is the material on which information processing occurs, and athletes, coaches, and teams use advanced analytics tools to glean meaningful information and feed into decision making processes.

Complex Systems Theory: Complex systems theory conceptualizes sports teams and their performance as dynamic, interdependent systems that are marked by nonlinear interactions and emergent properties. Big data analytics allows scientists to model and analyse the intricate interactions among players, tactics, and environmental conditions, and illuminate the underlying patterns and dynamics that affect performance outcomes.

Decision-Making Theory: Decision-making theory looks at the thinking processes and approaches that people utilize to make decisions in uncertain or changing situations. Coaches and athletes in sport are confronted continuously with decision-making problems, from tactical decisions within a game through designing training programs. Big data analytics offers decision support systems utilizing statistical models, machine learning routines, and predictive analytics to support better decision making and improve outcome.



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Social Network Theory: Social network theory examines the dynamics and structure of social ties in a network of actors. In sport, teams may be viewed as social networks, wherein players, coaches, and staff constitute nodes connected to one another. Communication, influence dynamics, and collaborative actions in sports teams, providing team cohesion, leadership dynamics, and performance optimization measures.

Performance Profiling Theory: Performance profiling theory is the systematic examination and analysis of athlete attributes, abilities, and performance measures. These profiles are utilized to discern strengths, weaknesses, and development areas, to inform tailored training interventions and performance optimization plans. In general, the theoretical underpinning of applying big data analytics in the analysis of sports performance is interdisciplinary in scope, utilizing knowledge from psychology, systems theory, decision science, social network analysis, and sports performance profiling. By combining these theoretical insights, researchers conceive new methods of using big data analytics to improve athlete development, maximize tactical strategies, and results in sport.

IV. PROPOSED METHODOLOGY

Application in performance analysis involves the use of ensuring collection, processing, and analysis of data are guided to meet study objectives and applicative purposes. Below is suggested methodology that contains an organized platform to incorporate for application in sports performance analysis.

Data Gathering: The initial process is finding relevant data sources and gathering heterogeneous datasets from a variety of sensors and tracking systems to video footage and statistical databases. Data collection processes can include real-time observations in training sessions and competitions as well as post-factum analysis of archived data. Thought must be taken for data quality, reliability, and validity in order to protect the integrity of the analysis.

Data Preprocessing: This process includes data cleaning, detection of outliers, imputation of missing values, and normalization to normalize the format of data and eliminate inconsistencies. Data integration techniques can also be used to combine different datasets into a common analytical framework.

Exploratory Data Analysis (EDA): EDA is to develop an enhanced understanding of the structure of analysis. This involves looking at important performance indicators, determining trends, correlations, and developing hypotheses for subsequent analysis.

Statistical Analysis: Statistical methods are used to quantify relationships, test hypotheses, and derive meaningful insights from the data.

Statistical Analysis: Statistical techniques are employed to measure relationships, make hypotheses, and develop useful conclusions from the data. Based on various statistical techniques could be employed, such as regression analysis, correlation analysis, hypothesis testing, and multivariate analysis.

Machine Learning and Predictive Modelling: Supervised learning algorithms, including regression, classification, and ensemble methods, are trained on past data to project future performance indicators, injury risks, and strategic outcomes. Unsupervised learning methodologies, including clustering and dimensionality reduction, can be applied to reveal concealed patterns and segment athlete populations according to performance traits.

Model Validation and Evaluation: Predictive models are validated based on relevant performance metrics like accuracy, precision, performance and ability to generalize. Cross validation methods like k-fold cross-validation and bootstrapping are used to ensure the robustness and reliability of the models with various datasets and conditions.

Implementation and Deployment: These recommendations can range from customized training programs and injury prevention procedures to game plans and lineup decisions. Feedback mechanisms and ongoing monitoring processes are set in place to monitor performance results and update the analytical models progressively.

Ethical Implications: Ethical implications on data privacy, informed consent, and confidentiality of participants have to be properly taken care of during the entire research process. The researchers need to follow ethical rules and



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guidelines on the collection, use, and sharing of athletes' data in order to ensure the protection of participants' rights and welfare.

V. COMPARATIVE ANALYSIS

A comparative examination of sports can offer in development, applications, and implications of this technology across various sports disciplines, organizational contexts, and analytical methods.

Data Complexity and Sources:

- **Team Sports:** Team sports such as soccer tend to use among several players, playing tactics, and environmental conditions. Data can be drawn from sources such as player tracking systems, match statistics, and video recording, capturing numerous facets of player movements, ball movements, and game dynamics.
- **Individual Sports:** For individual sports such as tennis, big data analytics targets the analysis of player performance metrics, stroke dynamics, and match statistics. Sources of data can be wearable sensors, video analysis software, and past match records, yielding information on players' biomechanics, shot choice, and match strategy.

Performance Metrics and Analysis:

- **Team Sports:** Team sport big data analysis focuses on studying aggregate performance data, like possession rates, pass completion percentages, and shooting conversions. Complex data analytics methods like network analysis and spatial-temporal modelling are utilized to assess team dynamics, player interactions, and strategic success.
- **Individual Sports:** In individual sports, big data analytics concentrates on player-specific performance metrics like serve speed, shot location, and movement patterns. Statistical methods, including regression analysis and pattern analysis, are applied to identify an individual's strength, weakness, and trend at the individual level.

Coaching and Tactical Insights:

- **Team Sports:** Big data analytics gives teams and coaches actionable insights to maximize tactical approaches. Predictive modelling and machine learning algorithms are employed to analyse opponent tendencies, model game situations, and make data-driven decisions during games.
- **Individual Sports:** In individual sports, big data analysis helps coaches and athletes design personalized training programs, hone techniques, and plan match strategy according to data insights. Video analysis software and performance monitoring systems help spot improvement areas, evaluate strengths of opponents, and create customized game plans.

Injury Prevention and Performance Optimization:

- **Team Sports:** Big data analytics is employed to track player workload, determine injury risk, and tailor training regimens to avoid injuries and improve performance. Physiological measurements, GPS data, and biomechanical analysis are employed to determine injury risk factors and create injury prevention protocols.
- **Individual Sports:** In individual sports, big data analysis assists the sportsperson in controlling training volume, tracking levels of fatigue, and avoiding overuse injuries. Wearable technology and performance-tracking devices give Realtime feedback regarding the intensity of training, recovery status, and biomechanical effectiveness, allowing athletes to peak in performance while keeping injury risks low.

Fan Engagement and Business Opportunities:

- **Team Sports:** Big data analytics enables fan engagement, spectator experience optimization, and top-line growth for sports organizations. Fan engagement platforms, content approaches driven by data, and targeting marketing campaigns exploit big data analytics to tailor fan experiences, engage fans, and optimize commercial value.
- **Individual Sports:** Individual sports big data analytics enables fan engagement through content, experience, and data storytelling. Metrics on athlete performances, match data, and historic records are utilized to craft strong narratives, mark critical moments, and interact with fans on online platforms.



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Overall, though there are parallels there are also significant differences in data complexity, performance indicators, coaching information, and business prospects. Through an understanding of these subtleties, sporting organizations can customize their analytical methodologies to maximize performance, maximize fan engagement, and achieve success within their respective sporting arenas.

VI. LIMITATIONS & DRAWBACKS

Despite the numerous benefits and opportunities associated with big data analytics in sports performance, there are several limitations and drawbacks that warrant consideration:

Data Quality and Reliability: One of the biggest problems in big data analytics is the guaranteeing of the reliability and quality of the data. In sports, data gathered from multiple sources can be error-prone, inconsistent, and biased, contaminating the integrity of the analysis.

Data Privacy and Ethical Issues: The storage, analysis, and collection of athlete data are serious privacy and ethical issues. Athlete rights to privacy, consent, and ownership over their data need to be upheld, and protection measures need to be in place against unauthorized access or exploitation of sensitive information. In addition, ethical issues surrounding informed consent, anonymization of data, and stewardship of data need to be addressed with caution to ensure that data driven practices are ethical and do not compromise the sporting community's trust and integrity.

Technological Limitations and Infrastructure Requirements: Big data analytics in sports performance demands strong technological infrastructure, such as data storage facilities, computing power, and analytical software. Small-scale sporting organizations or resource-poor settings can be devoid of the technological competencies and capacities required to harness the potential benefits of big data analytics, which restricts their potential to maximize its benefits. Additionally, technical constraints like data interoperability, compatibility problems, and integration issues can prevent data exchange and analysis between different platforms and systems.

Complexity and Interpretability: Complex statistical models and algorithms are frequently used in big data analytics that can be hard to interpret and comprehend, especially for non-technical stakeholders like coaches, athletes, and team managers. The black-box behavior of certain machine learning algorithms hides the decision-making processes behind them, and it can become difficult to trust and verify the outcomes.

Excessive Focus on Quantitative Measures: Although insights regarding the performance of athletes, it can ignore qualitative measures and intangible aspects of the sport, including teamwork, leadership, and resilience. Dependence on quantitative measures alone can devalue the subjective experience and holistic character of sporting performance, resulting in a reductionist and narrow conception of sporting success. A balance between quantitative analysis and qualitative observation and subjective evaluation is necessary to present a rich and multifaceted view of sporting performance.

Resistance to Change and Adoption Difficulties: The implementation of big data analytics in sports might stakeholders not willing to adapt to new technology and analytical methodology. Cultural issues, institutional reluctance, and concerns regarding the effectiveness of data-intensive practices could limit the extensive spread and integration of big data analytics within sports organizations.

Overcoming resistance to change requires proactive leadership, stakeholder buy-in, and organizational support to foster a culture of innovation, experimentation, and continuous improvement. Finally, great promise to revolutionize sports performance analysis, it has its strengths and weaknesses. Overcoming the limitations necessitates a comprehensive approach to include technological advancements, ethical issues, and organizational preparedness to exploit the full potential of big data analytics in sports.

VII. RESULTS AND DISCUSSION

The application of big data analytics in sports performance analysis has produced substantial outcomes and generated in-depth debates throughout the sports industry.



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Performance Optimization: Big data analytics athlete performance with data-driven information and customized interventions. Through analysis of performance indicators, biomechanical data, and physiological measures, coaches and sports scientists are able to spot areas for improvement, customize training programs, and improve athletic development strategies. Debate revolves around the efficacy of data-driven strategies in maximizing performance returns and gaining competitive edges in sport.

Tactical Innovation: Big data analytics has transformed tactical analysis and strategic planning within sports. Through analysis of opponent patterns, game flow, and player interactions, coaches are able to come up with more effective game plans, modify formations, and make on-field decisions with increased accuracy. Conversations delve into how data-based tactics influence game results, the roles of players, and strategic flexibility and the difficulties of combining quantitative information with qualitative aspects in tactical decision-making.

Injury Prevention and Risk Management: By tracking training loads, evaluating biomechanical stressors, and detecting injury risk factors, sports organizations can introduce specific interventions to reduce the risk of injuries and maximize player health and performance. Discussions revolve around the effectiveness of predictive modelling, real-time monitoring, and injury prevention protocols in lowering injury rates, improving player welfare, and extending athletic careers.

Fan Engagement and Experience Enhancement: Big data analytics is transforming fan experience and engagement strategy in sport. Through the use of fan data, behavioural information, and predictive analytics, sports organizations can offer personalized content, customize marketing efforts, and enhance fan interaction to optimize fan loyalty and revenue growth. Topics address new ways to engage fans, digital storytelling, and immersive experiences facilitated by big data analytics and the ethical implications of data-based fan engagement practice .

Ethical and Privacy Issues: The widespread application of significant ethical and privacy issues around data control, consent, and transparency. Debates centre on the establishment of clear guidelines, regulations, and ethical guidelines to control data collection, utilization, and data sharing among athletes, so data-driven practices will maintain ethical levels

Future Directions and Challenges: Future Directions and Challenges: Going forward, debate centres around cutting-edge trends, technological innovations, and directions of the future of big data analytics for the analysis of sports performance.

The conclusion, the findings and discussions of big data analytics in sports performance analysis highlight its potential to revolutionize performance enhancement, improve tactical approaches, reduce injury hazards, and enhance the experience of fans. Nevertheless, the fight against ethical issues, technology constraints, and the changing sport analytics environment continues to necessitate efforts to fully tap the power of big data in sports.

VIII. CONCLUSION

The integration in an into sports performance analysis represents a paradigm shift in how athletes train, coaches strategize, and teams compete. Throughout this paper, we have explored the multifaceted role of big data analytics in sports, highlighting its transformative impact on athlete development, tactical innovation, injury prevention, fan engagement, and ethical considerations. Big data analytics enables sports organizations to unlock valuable insights from vast quantities of data, providing a comprehensive understanding of athlete performance dynamics, tactical strategies, and fan behaviours. By leveraging advanced and predictive modelling, coaches and sports scientists can optimize training regimes, enhance strategic decision-making, and maximize performance outcomes while minimizing injury risks. Furthermore, big data analytics has revolutionized the fan experience, offering personalized content, immersive experiences, and interactive engagements that enhance fan loyalty and revenue generation for sports organizations. However, as big data analytics continues to evolve, it is essential to address ethical and privacy concerns, ensuring that data-driven practices uphold ethical standards and respect athletes' rights to privacy and consent. Looking ahead, the future of big data analytics in sports holds immense promise, with emerging trends such as artificial intelligence, wearable technology, and real-time analytics poised to further revolutionize sports performance analysis. By embracing innovation, collaboration, and responsible data stewardship, sports organizations can harness the full



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potential of big data analytics to optimize performance, drive strategic insights, and enrich the sporting experience for athletes, coaches, and fans alike.

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