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Review Article

Exploring the Integration and Implications of Artificial Intelligence Chatbots in the Realm of Sports Science Research, Training, and Rehabilitation

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Abstract

Background: The field of sports science has been fundamentally transformed by the integration of artificial intelligence (AI) technologies. AI has enabled advances in areas such as performance optimization, training personalization, injury risk assessment and prevention, talent recognition, rehabilitation, athlete monitoring, and wellness optimization**.**

Objective: This review aims to explore the diverse impact of AI in sports science, highlighting advances in AI techniques, the challenges and limitations of integrating AI tools, and the emerging role of AI chatbots in shaping the future of sports research and applications.

Methods: The review examines the existing literature on the application of machine learning, deep learning and other AI techniques in various aspects of sports science research and practice. It provides an overview of how these technologies have been used to improve personalized training programs, video analysis, injury risk prediction, talent identification, and rehabilitation.

Results: The article describes how AI-powered tools and techniques have revolutionized sports science, enabling personalized, data-driven and efficient approaches to performance optimization. Sophisticated machine learning algorithms such as artificial neural networks, decision trees and support vector machines have been used to develop predictive models for injury risk assessment and prevention, leading to improvements in athletes' wellbeing and long-term performance. AI-driven talent identification and selection processes have also shown promise in recognizing exceptional athletes with greater accuracy. In addition, the integration of AI into athlete monitoring and rehabilitation has led to greater personalization, better decision making and faster return to play.

Conclusion: The integration of AI and machine learning techniques into sports science has the potential to transform the field and lead to improved athlete performance, reduced risk of injury, improved well-being, and more personalized and effective interventions. The emergence of AI chatbots expands the applications of these technologies in sports science and offers new opportunities to streamline research processes, provide personalized advice to athletes and support sports medicine and rehabilitation.

Keywords: *ChatGPT, training load, LLM, Injury Prevention, Performance Optimization, large language model, Machine learning, Talent Identification.*

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1. Introduction

The field of sports science has undergone a profound transformation through the integration of artificial intelligence (AI) technologies. Researchers have increasingly explored the potential of advanced AI techniques to improve various aspects of athletic performance, injury prevention and data-driven decision making (1, 2). From optimizing training programs and predicting injury risk to analyzing biomechanics and managing large data sets, AI has become a powerful tool in the arsenal of sports scientists (3).

Recent studies have highlighted the significant impact of AI on the sports science landscape. Sophisticated machine

learning and deep learning algorithms have enabled the development of personalized training programs tailored to the individual needs and performance profiles of individual athletes (2, 4). Computer vision and motion tracking technologies combined with AI, have enabled more precise analysis of athletic movements and opened up new ways to optimize technique and improve performance (5, 6). In addition, the increasing availability of large sports datasets has enabled researchers to utilize AI-powered insights to address critical challenges such as injury risk assessment and prevention (2, 7).

However, the seamless integration of AI into sports science is not without its challenges. Concerns regarding data quality, model interpretability and ethical considerations, such as athlete privacy and performance manipulation, have emerged as critical factors that require careful navigation (8, 9). Furthermore, the integration of AI tools into existing sports science workflows and infrastructures presents a significant hurdle for researchers and practitioners.

Amidst this complexity, the emergence of AI chatbots has opened up new opportunities for sports science research and application. These intelligent virtual assistants have the potential to revolutionize the way sport scientists approach their work - from automating literature searches and meta-analyzes to providing personalized research insights and recommendations (10, 11). In addition, AI chatbots can play a central role in training, coaching and sports medicine by providing real-time feedback, personalized advice and fostering stronger engagement from injured athletes. (7, 12).

This review aims to explore the diverse impact of AI in sports science, highlighting the advances in AI techniques, the challenges and limitations of integrating AI tools, and the emerging role of AI chatbots in shaping the future of sports research and applications.

2. Performance optimization and training personalization

The integration of advanced machine learning and deep learning algorithms has revolutionized the way sports scientists approach performance optimization and training personalization. These sophisticated techniques have enabled the development of highly personalized training programs, tailored to the unique needs and performance profiles of individual athletes.

2.1. Use of Machine Learning and Deep Learning for Personalized Training Program.

Predictive models based on machine learning algorithms have shown the ability to identify the optimal training stimuli and recovery strategies for each athlete. Table 1 summarizes some commonly used machine learning techniques and their applications in sports science.

Table 1. Machine Learning Techniques for Personalized Training Programs

Technique	Application
Artificial Neural Networks	Modeling complex relationships between training load, physiological variables, and performance. More precise training plan prediction is made possible by these neural network models, which can adapt to individual athlete profiles and capture nonlinear interactions between factors (13, 14).
Decision Trees	Identifying key factors that influence athletic performance and injury risk. Decision tree algorithms can systematically evaluate a wide range of factors, such as training history, biomechanics, and environmental conditions, to determine the most important variables for training program design (15, 16).
Random Forests	Developing ensemble models for improved predictive accuracy in training optimization. By combining multiple decision trees, random forest models can provide more robust and reliable predictions, accounting for the inherent variability in athlete responses to training interventions (17, 18).
Support Vector Machines	Classifying athlete responses to different training interventions (19, 20). These supervised learning algorithms can effectively categorize athletes based on their physiological, biomechanical, and performance characteristics, making it possible to create training programs that are specifically customized for individual athlete profiles

By leveraging large data sets of training histories, physiological measurements and performance results, these machine learning models can create personalized training plans that take into account an individual's strengths and weaknesses and their response to different training methods (21).

Deep learning techniques in particular have shown promising results in improving the accuracy and personalization of training programs. Convolutional neural networks and recurrent neural networks have been used to analyze the complex relationships between an athlete's physical characteristics, training load, and performance metrics, leading to more effective and personalized training interventions (22, 23). These deep learning models can uncover intricate patterns and interactions within the data and provide sports scientists with a deeper understanding of the factors that contribute to optimal athletic performance.

2.2. *Video analysis tools for instant feedback*

The integration of computer vision and motion tracking technologies combined with AI, has revolutionized the way sports scientists analyze and provide feedback on athletic movements and techniques. Tools such as Coach's Eye and Dartfish use these technologies to provide real-time feedback and performance analysis, allowing coaches and athletes to quickly identify areas for improvement and adjust their training accordingly (24, 25).

These AI-powered video analysis tools can precisely quantify various biomechanical parameters such as joint angles, limb trajectories and movement patterns, providing athletes with immediate and objective feedback. This rapid feedback loop enables more efficient technique optimization and can lead to significant performance improvements, especially in sports that rely heavily on precise and efficient movement patterns (24). By recognising and correcting technical errors or sub-optimal movement patterns, athletes can enhance their execution and ultimately improve their overall performance (26) .

3. Injury risk assessment and prevention

The application of AI-driven prediction models and optimization techniques has shown great promise in the field of injury risk assessment and prevention, providing sports scientists and medical professionals with new tools to enhance athletes' well-being and performance

3.1. *Predictive models using artificial neural networks, decision trees, and support vector machines*

Sophisticated machine learning algorithms, such as artificial neural networks, decision trees and support vector machines, have been used to develop predictive models for assessing injury risk in athletes (27, 28). These models utilise a wide range of data, including demographic characteristics, training history, biomechanical parameters, and previous injuries, to identify the key factors that contribute to an athlete's susceptibility to certain types of injuries.

Artificial neural networks in particular have shown great potential in this area, as they are able to capture complex, non-linear relationships between different risk factors and injury outcomes (29, 30). By training these neural networks with comprehensive datasets, sports scientists can create highly accurate predictive models that can identify athletes at higher risk for certain injuries, such as ACL tears, hamstring strains or stress fractures. Due to the complex, interconnected risk factors for sports injuries, including biomechanical, physiological and psychological factors, artificial neural networks are ideally suited to this task as they can uncover intricate patterns and interactions within the data that are not easily detected using conventional statistical methods.

Decision tree algorithms have also been used to systematically analyze the relative importance of different risk factors and their interactions, providing sports medicine practitioners with a clear decision framework for injury risk assessment (31, 32). These decision tree-based models can be easily interpreted and translated into practical guidelines for injury prevention strategies. Sports and their contribution to an athlete's overall injury risk profile. This information can then be used to develop targeted interventions and adapt injury prevention programs accordingly.

On the other hand, support vector machines have proven their effectiveness in classifying athletes into different risk categories, allowing for more targeted interventions and personalized injury prevention programs (33, 34). These models can help allocate resources and implement customized prevention strategies for the most injury-prone athletes by accurately differentiating between high-risk and low-risk players. This approach is particularly useful in team sports, where the ability to identify and prioritize high-risk athletes can lead to more efficient and effective injury prevention strategies.

3.2. *AI-supported optimization of training methods for injury prevention*

In addition to prediction models, AI-based approaches have also been used to optimize training methods for the purpose of injury prevention (2, 35, 36), AI algorithms containing training histories, physiological reactions, and injury record data can identify the most effective training protocols, load management strategies and recovery practices that minimize the risk of sports injuries.

These AI-driven optimization techniques can help sports scientists and coaches develop training programs that take into account athletes' individual characteristics, training history and susceptibility to injury. The risk of overuse injuries and acute trauma by adjusting factors such as training selection, volume, intensity and recovery periods can be significantly reduced, leading to improved athlete health and long-term performance.

The applicability of these AI-driven strategies for injury risk assessment and prevention in sports science is

enormous. Sports medicine practitioners can, through the predictive power of machine learning and the optimization capabilities of AI: (i) identify athletes at higher risk for certain injuries, enabling targeted prevention strategies and early intervention, (ii) develop personalized training and rehabilitation programs that minimize injury risk while maximizing athletic performance, (iii) continuously refine and optimize training methods based on the feedback loop between athletes' data, (iv) gain deeper insights into the complex interactions between different risk factors, enabling a more comprehensive understanding of the mechanisms of sports injuries, and (v) improve athlete monitoring and decision making, leading to better long-term player health and a longer career.

The integration of AI-driven approaches in sports sciences has the potential to revolutionize injury prevention and management, ultimately leading to enhanced athlete well-being, reduced healthcare costs, and improved overall sports performance.

4. Identification and selection of talent

Identifying and selecting the most promising young athletes has long been a major concern of sports organizations and talent development programs. Conventional approaches to identifying talent frequently depend on subjective evaluations, which means they may miss some characteristics or fall short of realizing a person's full potential (37-39).

However, the integration of AI-powered predictive models and decision support systems has revolutionized the talent identification process (40, 41). AI systems can accurately predict an athlete's long-term potential and identify individuals most likely to excel in their respective sports. This has been based on understanding and analyzing data from performance metrics, physical characteristics, and development trajectories. New research has also highlighted the potential of using genomic data in conjunction with advanced machine learning and deep learning techniques to further improve the identification of talent.

Recent research has also highlighted the potential of using genomic data in conjunction with advanced machine learning and deep learning techniques to further improve talent identification and selection (42, 43). The field of sports genomics has uncovered numerous genetic markers and polymorphisms associated with various physical, physiological and cognitive attributes relevant to athletic performance (44-46).

, AI-driven predictive models that combine genomic data with other performance-related variables, such as training history, injury logs and ability assessments provide an even more comprehensive and accurate assessment of an athlete's potential (47, 48). In particular, deep learning algorithms have shown promise in uncovering complex, non-linear relationships between genetic factors and athletic ability.

For example, convolutional neural networks can be trained on genetic sequencing data combined with other performance measures to identify the specific genetic profiles that predict success in particular sports or even particular positions within a sport [15,16]. These deep learning models can recognize patterns and interactions within the genomic data that are not readily apparent using traditional statistical methods, leading to more robust and accurate talent identification.

Furthermore, the integration of genomics and AI can also enable the development of personalized training and development programs that take into account an athlete's unique genetic predispositions (43, 49). In this way, sports scientists can optimize their training methods and recovery strategies and ultimately improve the athlete's long-term development and performance (50).

The application of AI-driven talent identification, powered by the integration of genomic data, has the potential to revolutionize the way sports organizations identify, select, and develop talented athletes. The talent identification process can become more objective, efficient, and effective, leading to the nurturing of exceptional athletes who are better equipped to achieve their full potential.

5. Injury rehabilitation and optimization of return to play

The integration of AI and machine learning techniques has also significantly impacted the field of sports injury rehabilitation and return to play optimization. With the use of these advanced analytical tools, sports medicine professionals can improve the efficiency and effectiveness of the rehabilitation process, leading to better outcomes for patients and faster reintegration of athletes into their respective sports.

5.1. Personalized rehabilitation programs

One of the most important applications of AI in sports injury rehabilitation is the development of personalized rehabilitation programs (32, 51). Through the analysis of amounts of data, including individual injury history, biomechanical assessments and physiological responses, AI-

powered systems can create customized rehabilitation plans that address the individual needs and recovery trajectory of each athlete.

Machine learning algorithms, such as decision trees and random forests, can identify the most effective rehabilitation exercises, treatment modalities and progressions based on an athlete's specific injury, physical characteristics and response to previous interventions (52, 53). This personalized rehabilitation approach not only accelerates the healing process, but also minimizes the risk of re-injury by addressing the underlying factors that contributed to the original injury.

Furthermore, through the integration of wearable sensors and real-time monitoring, sports medicine professionals can gain valuable insights into the athlete's progress during rehabilitation (52, 53). These AI-driven systems can detect subtle changes and adaptations to dynamically adjust the rehabilitation program to optimize the athlete's recovery.

5.2. Prediction of return-to-play timelines

Accurately predicting the timeframe for an athlete's safe return to play after an injury is a key challenge in sports medicine. To date, this assessment has been heavily dependent on clinicians' subjective judgments, which can be influenced by various factors and lead to inconsistent results.

However, the application of AI-powered prediction models has significantly improved the accuracy and reliability of return-to-play timelines (54, 55). These models can identify the key factors that influence an athlete's readiness to safely return to competition.

In particular, artificial neural networks can capture the complex, non-linear relationships between various recovery parameters and the likelihood of a successful return to play (56). These predictive models can help sports medicine practitioners

5.3. Automated decision support systems

In addition to personalized rehabilitation programs and return-to-play predictions, the integration of AI has also led to the development of automated decision support systems that can assist sports medicine practitioners in clinical decision-making (57, 58).

These AI-powered systems can integrate multiple data sources such as medical history, imaging and treatment outcomes to provide real-time recommendations and decision support for the treatment of sports injuries. Through the use of machine learning algorithms, these systems can recognize patterns and trends that are not immediately apparent to human clinicians, leading to more informed and efficient decision making.

Implementing these automated decision support systems can improve consistency and quality of care while freeing up valuable time for sports medicine clinicians to focus on other aspects of athlete management and rehabilitation.

6. Athlete monitoring and performance optimization

The integration of AI and machine learning techniques has also had a significant impact on the realm of athlete monitoring and performance optimization, sports organizations can gain unprecedented insights into an athlete's physical, physiological, and cognitive states, enabling more effective training and competition strategies.

6.1. Comprehensive athlete monitoring

Effective athlete monitoring is essential for sports organizations to understand the multifaceted factors that contribute to an athlete's performance, health, and well-being. Traditionally, this process has relied on a combination of subjective assessments, periodic testing, and limited data collection.

However, the advent of AI-driven athlete monitoring systems has transformed this landscape, providing sports scientists and coaches with a more comprehensive and objective understanding of an athlete's condition (7, 59). These systems integrate data from a wide range of sources, including wearable sensors, video analysis, and comprehensive physiological and psychological assessments, to create a holistic profile of the athlete's current state. In this way, AI-powered systems can detect subtle changes and deviations from their baseline, enabling early intervention and proactive management of any emerging concerns.

6.2. Modeling predictive performance

Building on athlete monitoring capabilities, predictive performance modeling driven by AI has become a valuable tool for enhancing sports performance. These models use the data collected from monitoring systems, along with past performance records and external factors, to forecast an athlete's chances of success in upcoming competitions.

Artificial neural networks, especially, have shown their ability to understand the intricate connections between different performance variables and the probability of

achieving certain results (60, 61) By teaching these neural networks with large amounts of data, sports organizations can create predictive models that can anticipate an athlete's potential for top performance and pinpoint any obstacles that could impede their success.

These predictive models can be used to inform training and competition strategies, allowing coaches and sports scientists to make data-driven decisions that maximize an athlete's chances of success. For example, the models may identify specific areas where an athlete needs to focus their training efforts or suggest optimal pacing strategies for a particular event based on their predicted performance.

6.3. AI-powered training optimization

Building on the knowledge gained from comprehensive athlete monitoring and predictive performance modeling, AI-assisted training optimization has become a pioneering approach in the sports performance landscape. Through the use of AI algorithms, sports organizations can analyze the vast amounts of data collected on an athlete's training history, physiological responses and competition results to determine the most effective training methods and optimize the training process (62, 63).

This includes the optimization of training load, exercise selection, recovery strategies and periodization, all of which are tailored to the needs and characteristics of the individual athlete.

For example, reinforcement learning algorithms can be employed to continuously evaluate the athlete's responses to different training stimuli and dynamically adjust the training program to achieve the desired adaptations and performance results. This iterative process of experimentation, evaluation and refinement can lead to significant improvements in an athlete's overall development and performance. The integration of AI and machine learning into the field of athlete monitoring and performance optimization has the potential to revolutionize the way sports organizations approach the training and development of their athletes

7. . Athlete welfare and wellbeing optimization

The integration of AI and machine learning has also impacted the area of optimizing athlete well-being. Sports organizations can gain a deeper understanding of the multiple factors that contribute to an athlete's physical, mental and social wellbeing, enabling more targeted and effective support systems.

7.1. Comprehensive monitoring of athlete wellbeing

Maintaining athletes' overall well-being is critical to their long-term success and sustainability in sport. To date, the assessment of an athlete's well-being has relied on a combination of self-reporting, regular check-ups and limited data collection. The emergence of AI-driven athlete wellbeing monitoring systems has changed this landscape, providing sports organizations with a more comprehensive and objective understanding of an athlete's physical, mental and social wellbeing (64-66). These systems integrate data from a variety of sources, including wearable sensors, psychological assessments and social interactions, to provide a holistic profile of the athlete's current state. By continuously monitoring an athlete's overall well-being, AI-powered systems can detect subtle changes and deviations from baseline, allowing for early intervention and proactive management of emerging issues

7.2. Personalized interventions for holistic wellbeing

Sports organizations by using athlete wellness monitoring and predictive modelling can develop personalized interventions and support systems to address the holistic well-being of their athletes. AI-powered decision support systems can integrate various data sources, including physical, mental, and social well-being indicators, to provide tailored recommendations for nutrition, psychological counselling, social engagement, and other holistic support measures (67, 68). These personalized interventions can address the specific needs and challenges faced by individual athletes, ensuring a comprehensive approach to their overall well-being.

Furthermore, the use of natural language processing and sentiment analysis techniques can enable the identification of potential mental health concerns or psychological distress, allowing sports organizations to proactively provide the necessary support and resources. AI-driven interventions can contribute to enhanced performance, reduced injury risk, and improved long-term career sustainability(69).

8. AI Chatbots or Large language models (LLM) in sports medicine and exercise sciences

8.1. Assisting with literature searches and screening

The use of AI chatbots can aid researchers in efficiently navigating the expansive body of scientific literature relevant to their inquiries. These chatbots support natural language processing capabilities to understand researchers'

queries and provide suggestions for potentially relevant studies based on keywords, abstracts, and other metadata (70). However, it is important to note that the critical processes of reviewing, screening, and selecting appropriate studies for literature reviews or meta-analyses still require human expertise and judgment.

8.2. Providing personalized research insights and recommendations

AI chatbots can provide personalized suggestions for relevant studies, potential collaborators, funding opportunities, and emerging research trends by examining a researcher's interests, expertise, and current projects (71). This can help researchers stay abreast of the latest developments in their field and identify novel avenues for exploration, which can improve the productivity and focus of their research efforts.

8.3. Facilitating academic writing and collaboration

AI chatbots can also assist researchers with the academic writing process, providing suggestions for structure, grammar, and appropriate academic language (72-74). Furthermore, these chatbots can facilitate collaborative efforts among research teams by coordinating tasks, managing version control, and offering real-time feedback on shared documents

8.4. AI chatbots as training and coaching assistants

AI chatbots have proven to be versatile tools in the field of sports science, offering a wide range of applications in the areas of training, training guidelines, nutrition and even psychological support. In contrast to the speculative applications of earlier discussions, where AI were portrayed as futuristic beings capable of performing real-time biomechanical analysis and providing instant feedback on technique, current opportunities are more focused on personalizing training programs, optimizing performance, and improving athlete well-being through accessible and scalable solutions (75).

Large-scale language models (LLMs) such as ChatGPT, Google Gemini and similar platforms are becoming an integral part of providing tailored training prescriptions, especially for athletes and coaches who do not have constant access to specialized human sneakers. These chatbots, when integrated with wearable technology and athlete data, can develop training routines based on individual health profiles, fitness levels and goals. For example, ChatGPT can analyze performance data such as heart rate variability or recovery times and recommend specific adjustments to an athlete's training load or recovery strategies to reduce injury risk and improve performance outcomes outcomes (75, 76).

Recent research has supported the role of AI in creating personalized training plans. Guelmami, Fekih-Romdhane (35), for example, have shown that AI systems can help athletes optimize their training and recovery by analyzing their performance data, injury history and personal goals. Similarly, studies have shown that AI can assist in the dynamic adaptation of training loads based on real-time feedback from body-worn sensors, although the ability to make such interventions remains limited to data processing rather than biomechanical assessments (77, 78).

AI chatbots are also playing an increasingly important role in nutrition and recovery planning. They provide athletes with personalized nutritional advice based on calorie needs, macronutrient breakdown and performance goals. These tools can adapt nutrition plans to changing training phases, such as tapering periods or injury recovery, to ensure athletes maintain peak performance while reducing the risk of overtraining or burnout (79, 80).

Furthermore, AI chatbots are becoming invaluable tools for sports psychology support. Athlete mental health is a critical area that is gaining increasing attention, and chatbots are proving to be effective tools for psychological support. Through the use of natural language processing (NLP), AI chatbots can engage with athletes and offer them motivation, stress management strategies and even simple mental exercises to increase concentration and reduce anxiety before competitions (81, 82). This mental health support, when combined with personalized training recommendations, contributes to a holistic approach to athlete development.

In rehabilitation, AI chatbots have shown great potential as virtual rehab coaches. Garbett, Degutyte (83) have highlighted how these systems can provide continuous feedback, encouragement and reminders to athletes recovering from injury. By integrating with wearable devices, these chatbots can monitor rehabilitation progress and suggest changes to rehabilitation exercises in real time to ensure the athlete is undergoing a safe and effective recovery process. For example, they can detect deviations in movement patterns or reduced adherence to prescribed exercises and intervene with corrective feedback or motivational prompts.

Importantly, AI chatbots are not stand-alone solutions, but act as collaborative tools alongside sneakers, sports

scientists and medical professionals (84). They serve as virtual assistants that facilitate communication between athletes and their support teams by streamlining data analysis and report generation. They also help coordinate logistics, such as scheduling, training session reminders and recovery monitoring, reducing the administrative burden on sneakers and allowing them to focus more on high-level strategic planning (75).

One of the most significant advances in AI chatbot applications is in the area of initial injury assessment and triage. Studies by Ha, Yu (85) and others have shown that AI-powered chatbots can assist sports medicine physicians in the preliminary assessment of injuries based on athletes' symptom descriptions. This can determine whether an injury is serious enough to require immediate medical treatment or whether the athlete can continue with modified training. Such early interventions are important to prevent further injury and ensure timely treatment.

To summarize, AI chatbots such as ChatGPT and Google Gemini are no longer just theoretical tools, but are already being actively used to improve training, recovery, nutrition and psychological support for athletes. As technology continues to evolve, these applications offer practical, evidence-based benefits that can improve athlete performance, optimize training efficiency and support comprehensive rehabilitation. Future advances could offer even greater opportunities, but the current integration of AI chatbots into sports science is already very promising.

9. Conclusion

The integration of AI and machine learning techniques into sports science has immense potential to transform various aspects of sports performance, well-being and rehabilitation. Advances in AI-powered tools have enabled personalized, data-driven approaches to training optimization, injury prevention, talent identification and athlete monitoring. These innovations can lead to significant performance gains by allowing technique optimization and personalized training programs, improving athlete well-being through predictive injury risk assessment models, revolutionizing talent identification and development, accelerating rehabilitation and return-to-play processes, and optimizing research and consultation through AI chatbots.

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Conceptualization, T.H., R.B., H.G.; methodology, H.G., N.G.; writing -original draft preparation, T.H., R.B.; data analysis, T.H., N.G.; writing -review and editing, T.H., N.G., R.B., H.G. All authors have read and agreed to the published version of the manuscript.

Declaration

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References

1. Chmait N, Westerbeek H. Artificial intelligence and machine learning in sport research: An introduction for non-data scientists. Frontiers in sports and active living. 2021;3:682287. [DOI]
2. Bodemer O. Enhancing Individual Sports Training through Artificial Intelligence: A Comprehensive Review. Authorea Preprints. 2023. [DOI]
3. Rico-González M, Pino-Ortega J, Méndez A, Clemente F, Baca A. Machine learning application in soccer: a systematic review. Biology of sport. 2023;40(1):249-63. [DOI]
4. Cust EE, Sweeting AJ, Ball K, Robertson S. Machine and deep learning for sport-specific movement recognition: A systematic review of model development and performance. Journal of sports sciences. 2019;37(5):568-600. [DOI]

5. Brunetti A, Buongiorno D, Trotta GF, Bevilacqua V. Computer vision and deep learning techniques for pedestrian detection and tracking: A survey. Neurocomputing. 2018;300:17-33. [DOI]
6. O'Mahony N, Campbell S, Carvalho A, Harapanahalli S, Hernandez GV, Krpalkova L, et al. Deep learning vs. traditional computer vision. Advances in Computer Vision: Proceedings of the 2019 Computer Vision Conference (CVC), Volume 1 1. 2020:128-44. [DOI]
7. Li A, Huang W. A comprehensive survey of artificial intelligence and cloud computing applications in the sports industry. Wireless Networks. 2023:1-12. [DOI]
8. Naughton M, Salmon PM, Compton HR, McLean S. Challenges and opportunities of artificial intelligence implementation within sports science and sports medicine teams. Front Sports Act Living. 2024;6:1332427. [PMCID: PMC11144926] [DOI]
9. Chen P, Wu L, Wang L. AI fairness in data management and analytics: A review on challenges, methodologies and applications. Applied Sciences. 2023;13(18):10258. [DOI]
10. Chakraborty U. Artificial Intelligence for All: Transforming Every Aspect of Our Life: Bpb publications; 2020.
11. Araújo D, Couceiro M, Seifert L, Sarmento H, Davids K. Artificial intelligence in sport performance analysis: Routledge; 2021.
12. McBee JC, Han DY, Liu L, Ma L, Adjeroh DA, Xu D, et al. Interdisciplinary inquiry via PanelGPT: application to explore chatbot application in sports rehabilitation. medRxiv. 2023. [DOI]
13. Carrard J, Kloucek P, Gojanovic B. Modelling training adaptation in swimming using artificial neural network geometric optimisation. Sports. 2020;8(1):8. [DOI]
14. Bourdon PC, Cardinale M, Murray A, Gastin P, Kellmann M, Varley MC, et al. Monitoring athlete training loads: consensus statement. International journal of sports physiology and performance. 2017;12(s2):S2-161-S2-70. [DOI]
15. Zhang Z, Zhao Z, Yeom D-S. [Retracted] Decision Tree Algorithm-Based Model and Computer Simulation for Evaluating the Effectiveness of Physical Education in Universities. Complexity. 2020;2020(1):8868793. [DOI]
16. Charbuty B, Abdulazeez A. Classification based on decision tree algorithm for machine learning. Journal of Applied Science and Technology Trends. 2021;2(01):20-8. [DOI]
17. Dorschky E, Camomilla V, Davis J, Federolf P, Reenalda J, Koelewijn AD. Perspective on "in the wild" movement analysis using machine learning. Human movement science. 2023;87:103042. [DOI]
18. Aria M, Cuccurullo C, Gnasso A. A comparison among interpretative proposals for Random Forests. Machine Learning with Applications. 2021;6:100094. [DOI]
19. Burdack J, Horst F, Aragonés D, Eekhoff A, Schöllhorn WI. Fatigue-related and timescale-dependent changes in individual movement patterns identified using support vector machine. Frontiers in psychology. 2020;11:551548. [DOI]
20. Lei T, Cai Z, Hua L. Training prediction and athlete heart rate measurement based on multi-channel PPG signal and SVM algorithm. Journal of Intelligent & Fuzzy Systems. 2021;40(4):7497-508. [DOI]
21. Dergaa I, Chamari K. Big Data in Sports Medicine and Exercise Science: Integrating Theory and Practice for Future Innovations. Tunisian Journal of Sports Science and Medicine. 2024;2(1):1-13. [DOI]
22. Alghamdi WY. A novel deep learning method for predicting athletes' health using wearable sensors and recurrent neural networks. Decision Analytics Journal. 2023;7:100213. [DOI]
23. Yang C, Chang Y-T. Data Collection And Performance Evaluation Of Running Training Sport Using Different Neural Network Techniques. Journal of Mechanics in Medicine and Biology. 2023;23(04):2340053. [DOI]
24. Cossich VR, Carlgren D, Holash RJ, Katz L. Technological breakthroughs in sport: Current practice and future potential of artificial intelligence, virtual reality, augmented reality, and modern data visualization in performance analysis. Applied Sciences. 2023;13(23):12965. [DOI]
25. Zulkifli AF, Danis A. Technology in physical education: Using movement analysis application to improve feedback on sports skills among undergraduate physical education students. Social Sciences & Humanities Open. 2022;6(1):100350. [DOI]
26. Fessi MS, Oliveira RFS. Outside the Lab: A Practical Perspective Transition in Sports Science Research. Tunisian Journal of Sports Science and Medicine. 2023;1(1):4-7. [DOI]
27. Van Eetvelde H, Mendonça LD, Ley C, Seil R, Tischer T. Machine learning methods in sport injury prediction and prevention: a systematic review. Journal of experimental orthopaedics. 2021;8:1-15. [PMID: 33855647] [PMCID: PMC8046881] [DOI]
28. Seow D, Graham I, Massey A. Prediction models for musculoskeletal injuries in professional sporting activities: a systematic review. Translational Sports Medicine. 2020;3(6):505-17. [DOI]
29. Kakavas G, Malliaropoulos N, Pruna R, Maffulli N. Artificial intelligence: a tool for sports trauma prediction. Injury. 2020;51:S63-S5. [DOI]
30. Fonseca ST, Souza TR, Verhagen E, Van Emmerik R, Bittencourt NF, Mendonça LD, et al. Sports injury forecasting and complexity: a synergetic approach. Sports medicine. 2020;50:1757-70. [DOI]
31. Jauhiainen S, Kauppi J-P, Leppänen M, Pasanen K, Parkkari J, Vasankari T, et al. New machine learning approach for detection of injury risk factors in young team sport athletes. International journal of sports medicine. 2021;42(02):175-82. [DOI]
32. Yung KK, Ardern CL, Serpiello FR, Robertson S. Characteristics of complex systems in sports injury rehabilitation: examples and implications for practice. Sports medicine-open. 2022;8(1):24. [DOI]
33. Lu Y, Pareek A, Lavoie-Gagne OZ, Forlenza EM, Patel BH, Reinholz AK, et al. Machine learning for predicting lower extremity muscle strain in national basketball association athletes. Orthopaedic Journal of Sports Medicine. 2022;10(7):23259671221111742. [DOI]
34. Iduh BN, Umeh MN, Anusiuba OI, Egba FA. Development of a Predictive Modeling Framework for Athlete Injury Risk Assessment and Prevention: A Machine Learning Approach. European Journal of Theoretical and Applied Sciences. 2024;2(4):894-906. [DOI]
35. Guelmami N, Fekih-Romdhane F, Mechraoui O, Bragazzi NL. Injury Prevention, Optimized Training and Rehabilitation: How Is AI Reshaping the Field of Sports Medicine. New Asian Journal of Medicine. 2023;1(1):30-4. [DOI]
36. Forelli F, Aloui IB, Mazeas J, Hewett TE, Douryang M. Strategies for Injury Prevention and Enhancing Performance. Tunisian Journal of Sports Science and Medicine. 2024;2(3):1-5.
37. Höner O, Larkin P, Leber T, Feichtinger P. Talent identification and development in sport: Springer; 2023. 549-81 p
38. Atanasov P, Himmelstein M. Talent spotting in crowd prediction: Springer; 2023. 135-84 p[DOI]

39. Ghouili H, Farhani Z, Amara S, Hattabi S, Dridi A, Guelmami N, et al. Normative data in resting and maximum heart rates and a prediction equation for young Tunisian soccer players: a cross-sectional study. EXCLI journal. 2023;22:670.
40. Judijanto L, Asfahani A, Bakri AA, Susanto E, Kulsum U. AI-Supported Management through Leveraging Artificial Intelligence for Effective Decision Making. Journal of Artificial Intelligence and Development. 2022;1(1):59-68.
41. Khan MR. Application of artificial intelligence for talent management: Challenges and opportunities. Intelligent Human Systems Integration (IHSI 2024): Integrating People and Intelligent Systems. 2024;119(119). [DOI]
42. Garg S, Sinha S, Kar AK, Mani M. A review of machine learning applications in human resource management. International Journal of Productivity and Performance Management. 2022;71(5):1590-610. [DOI]
43. Tanisawa K, Wang G, Seto J, Verdouka I, Twycross-Lewis R, Karanikolou A, et al. Sport and exercise genomics: the FIMS 2019 consensus statement update. British journal of sports medicine. 2020;54(16):969-75. [DOI]
44. Semenova EA, Hall EC, Ahmetov II. Genes and athletic performance: the 2023 update. Genes. 2023;14(6):1235. [DOI]
45. Youn B-Y, Ko S-G, Kim JY. Genetic basis of elite combat sports athletes: a systematic review. Biology of sport. 2021;38(4):667. [DOI]
46. Dergaa I, Ben Saad H, Glenn JM, Amamou B, Ben Aissa M, Guelmami N, et al. From tools to threats: a reflection on the impact of artificial-intelligence chatbots on cognitive health. Frontiers in Psychology. 2024;15:1259845. [DOI]
47. Caudai C, Galizia A, Geraci F, Le Pera L, Morea V, Salerno E, et al. AI applications in functional genomics. Computational and Structural Biotechnology Journal. 2021;19:5762-90. [DOI]
48. Chakraborty C, Bhattacharya M, Pal S, Lee S-S. From machine learning to deep learning: An advances of the recent data-driven paradigm shift in medicine and healthcare. Current Research in Biotechnology. 2023:100164. [DOI]
49. Ginevičienė V, Utkus A, Pranckevičienė E, Semenova EA, Hall EC, Ahmetov II. Perspectives in sports genomics. Biomedicines. 2022;10(2):298. [DOI]
50. Bouguezzi R, Chaabene H. Periodization: A Strategic Influence in Athletics and Academics. Tunisian Journal of Sports Science and Medicine. 2024;2(1):21-4. [DOI]
51. Lloyd D. The future of in-field sports biomechanics: Wearables plus modelling compute real-time in vivo tissue loading to prevent and repair musculoskeletal injuries. Sports Biomechanics. 2021:1-29. [DOI]
52. Islam MM. Exploring the Impact of Artificial Intelligence in Healthcare. Journal of Artificial Intelligence General science (JAIGS) ISSN: 3006-4023. 2024;2(1):228-38. [DOI]
53. Lacinski RA, Steller JG, Anderson A, Nelson AM. Harnessing Artificial Intelligence for Medical Diagnosis and Treatment During Space Exploration Missions. 2024. [DOI]
54. Li B, Wang L, Jiang Q, Li W, Huang R. Sports Risk Prediction Model based on automatic encoder and convolutional neural network. Applied Sciences. 2023;13(13):7839. [DOI]
55. Papageorgiou G, Sarlis V, Tjortjis C. Unsupervised Learning in NBA Injury Recovery: Advanced Data Mining to Decode Recovery Durations and Economic Impacts. Information. 2024;15(1):61. [DOI]
56. Munoz-Macho AA, Domínguez-Morales MJ, Sevillano-Ramos JL. Performance and healthcare analysis in elite sports teams using artificial intelligence: a scoping review. Frontiers in Sports and Active Living. 2024;6:1383723. [DOI]
57. Abbasgholizadeh Rahimi S, Cwintal M, Huang Y, Ghadiri P, Grad R, Poenaru D, et al. Application of artificial intelligence in shared decision making: scoping review. JMIR Medical Informatics. 2022;10(8):e36199. [DOI]
58. Loftus TJ, Tighe PJ, Filiberto AC, Efron PA, Brakenridge SC, Mohr AM, et al. Artificial intelligence and surgical decision-making. JAMA surgery. 2020;155(2):148-58. [DOI]
59. Shen D, Tao X, Koncar V, Wang J. A Review of Intelligent Garment System for Bioelectric Monitoring During Long-Lasting Intensive Sports. IEEE Access. 2023. [DOI]
60. Rodríguez-Hernández CF, Musso M, Kyndt E, Cascallar E. Artificial neural networks in academic performance prediction: Systematic implementation and predictor evaluation. Computers and Education: Artificial Intelligence. 2021;2:100018. [DOI]
61. Samek W, Montavon G, Lapuschkin S, Anders CJ, Müller K-R. Explaining deep neural networks and beyond: A review of methods and applications. Proceedings of the IEEE. 2021;109(3):247-78. [DOI]
62. Liu T, Wilczyńska D, Lipowski M, Zhao Z. Optimization of a sports activity development model using artificial intelligence under new curriculum reform. International Journal of Environmental Research and Public Health. 2021;18(17):9049. [DOI]
63. Wei S, Huang P, Li R, Liu Z, Zou Y. Exploring the application of artificial intelligence in sports training: a case study approach. Complexity. 2021;2021(1):4658937. [DOI]
64. Xia Q. Fostering Athletes' Mental Resilience: Artistic Innovation and AI in Sports. Revista de Psicología del Deporte (Journal of Sport Psychology). 2023;32(4):213-24.
65. Sampedro AC. The Ethics of AI in Sport. Taking athletes' rights and wellbeing seriously2023.
66. Dergaa I, Saad HB, El Omri A, Glenn J, Clark C, Washif J, et al. Using artificial intelligence for exercise prescription in personalised health promotion: A critical evaluation of OpenAI's GPT-4 model. Biology of Sport. 2024;41(2):221-41. [DOI]
67. Coman L-I, Ianculescu M, Paraschiv E-A, Alexandru A, Bădărău I-A. Smart Solutions for Diet-Related Disease Management: Connected Care, Remote Health Monitoring Systems, and Integrated Insights for Advanced Evaluation. Applied Sciences. 2024;14(6):2351. [DOI]
68. Panejar A. Precision health and artificial intelligence. Nueva York: Apress. 2023. [DOI]
69. Al Naqbi H, Bahroun Z, Ahmed V. Enhancing work productivity through generative artificial intelligence: A comprehensive literature review. Sustainability. 2024;16(3):1166. [DOI]
70. Anthes E. The shape of work to come. Nature. 2017;550(7676):316-9. [DOI]
71. Markoff J. Machines of loving grace: The quest for common ground between humans and robots: HarperCollins Publishers; 2016.
72. Song C, Song Y. Enhancing academic writing skills and motivation: assessing the efficacy of ChatGPT in AI-assisted language learning for EFL students. Frontiers in Psychology. 2023;14:1260843. [DOI]
73. Dergaa I, Chamari K, Glenn JM, Aissa MB, Guelmami N, Saad HB. Towards responsible research: examining the need for preprint policy reassessment in the era of artificial intelligence. EXCLI journal. 2023;22:686.

74. Dergaa I, Saad HB. Artificial Intelligence and Promoting Open Access in Academic Publishing Intelligence artificielle et promotion de l'accès libre dans la publication académique. La Tunisie medicale. 2023;101(06):533-6.
75. Dergaa I, Fekih-Romdhane F, Glenn JM, Fessi MS, Chamari K, Dhahbi W, et al. Moving beyond the stigma: understanding and overcoming the resistance to the acceptance and adoption of artificial intelligence chatbots. New Asian Journal of Medicine. 2023;1(2):29-36. [DOI]
76. Washif J, Pagaduan J, James C, Dergaa I, Beaven C. Artificial intelligence in sport: Exploring the potential of using ChatGPT in resistance training prescription. Biology of sport. 2024;41(2):209-20. [DOI]
77. Poulsen A, Burmeister OK, Kreps D. The ethics of inherent trust in care robots for the elderly. IFIP International Conference on Human Choice and Computers. 2018:314-28. [DOI]
78. Wang Y, Shan G, Li H, Wang L. A wearable-sensor system with AI technology for real-time biomechanical feedback training in hammer throw. Sensors. 2022;23(1):425. [DOI]
79. Dergaa I, Saad HB, Ghouili H, Glenn JM, El Omri A, Slim I, et al. Evaluating the Applicability and Appropriateness of ChatGPT as a Source for Tailored Nutrition Advice: A Multi-Scenario Study. New Asian Journal of Medicine. 2024;2(1):1-16. [DOI]
80. Sosa-Holwerda A, Park O-H, Albracht-Schulte K, Niraula S, Thompson L, Oldewage-Theron W. The role of artificial intelligence in nutrition research: a scoping review. Nutrients. 2024;16(13):2066. [DOI]
81. Dergaa I, Fekih-Romdhane F, Hallit S, Loch AA, Glenn JM, Fessi MS, et al. ChatGPT is not ready yet for use in providing mental health assessment and interventions. Frontiers in Psychiatry. 2024;14:1277756. [DOI]
82. Omarov B, Zhumanov Z, Gumar A, Kuntunova L. Artificial intelligence enabled mobile chatbot psychologist using AIML and cognitive behavioral therapy. International Journal of Advanced Computer Science and Applications. 2023;14(6). [DOI]
83. Garbett A, Degutyte Z, Hodge J, Astell A. Towards understanding people's experiences of ai computer vision fitness instructor apps. Proceedings of the 2021 ACM Designing Interactive Systems Conference. 2021:1619-37. [DOI]
84. Waisberg E, Ong J, Masalkhi M, Zaman N, Sarker P, Lee AG, et al. A Comparative Analysis of ChatGPT and Google's AI's "Bard" in Medicine. New Asian Journal of Medicine. 2023;1(2):37-43. [DOI]
85. Ha T, Yu H, Lim B, Jung HY, Brooks C, Krause J, et al. Using ChatGPT in the field of kinesiology: Opportunities and considerations. Journal of Physical Education and Sport. 2024;24(1):3-12.