





Injury Prevention, Optimized Training and Rehabilitation: How Is AI Reshaping the Field of Sports Medicine

Noomen Guelmami, Ph.D ^{1,2*} , Feten Fekih-Romdhane, M.D, Ph.D ^{3,4} , Oumaima Mechraoui, M.Sc ⁵ , Nicola L. Bragazzi, Ph.D ⁶ 

¹ Department of Human and Social Sciences, Higher Institute of Sport and Physical Education of Kef, University of Jendouba, Jendouba, Tunisia

² Postgraduate School of Public Health, Department of Health Sciences (DISSAL), University of Genoa, Genoa, Italy

³ The Tunisian Center of Early Intervention in Psychosis, Department of Psychiatry "Ibn Omrane", Razi Hospital, 2010, Manouba, Tunisia

⁴ Department of Health, Higher Institute of Nursing Sciences of Kef, University of Jendouba, Jendouba, Tunisia

⁵ Interdisciplinary Laboratory in Neurosciences, Physiology and Psychology: Physical Activity, Health and Learning, UFR STAPS, UPL, Paris Nanterre University, Nanterre, France

⁶ Laboratory for Industrial and Applied Mathematics (LIAM), Department of Mathematics and Statistics, York University, Toronto, ON M3J 1P3, Canada

* **Corresponding Author:** Dr. Noomen Guelmami, PH.D., M.Sc., Postgraduate School of Public Health, Department of Health Sciences (DISSAL), University of Genoa, Genoa, Italy. E-mail: noomen4@yahoo.fr

Received: 2023-06-17

Reviewed: 2023-06-27

Re-submitted: 2023-07-12

Accepted: 2023-08-01

Published: 2023-08-23

Keywords: Athletics, Injury Risk, Kinesiology, Machine Learning, Smart Watch, Training Load

How to cite this paper: Guelmami N, Fekih-Romdhane F, Mechraoui O, L. Bragazzi N. Injury Prevention, Optimized Training and Rehabilitation: How Is AI Reshaping the Field of Sports Medicine. N Asian J Med. 2023;1(1):30-34. doi: 10.61838/kman.najm.1.1.6

INTRODUCTION

As we progress in the digital age, the adoption of artificial intelligence (AI) into various sectors is noticeably growing. Crucial components of AI, including deep learning, adaptability, and sensory perception, are playing pivotal roles in this digital shift (1). AI technology, with its advanced data analytics, pattern recognition, and learning from experience, enhances decision-making and problem-solving processes (2, 3). The intent is to improve human-computer interaction through innovative engagement strategies and natural language processing.

In the context of sports medicine, AI brings a promising shift, offering substantial potential transformations. It opens up opportunities for injury prevention, training optimization, and developments in rehabilitation procedures (4). Thanks to its ability to process and analyse large data volumes, AI can provide significant insights. This intersection of technology and medical care suggests that AI is set to bring unprecedented changes to sports medicine.

The numerous applications of artificial intelligence in sports medicine, including injury prevention, performance enhancement, rehabilitation and recovery, and the necessary ethical considerations, are outlined in [Figure 1](#). This editorial aims to underscore the potential advantages of using AI in sports medicine, focusing particularly on injury prevention, training optimization, and post-injury rehabilitation.

AI TO IMPROVE INJURY PREVENTION

Injury prevention remains a central concern in sports medicine, where AI is emerging as an indispensable tool. The ability of AI to enhance injury prevention is substantial. By employing AI algorithms to analyse player performance data, biomechanical factors, and physiological indicators, we can recognize trends and flag potential injury risks (5). With the assistance of machine learning, sports medicine specialists can construct programs aimed at injury prevention. These programs utilize optimal training loads and techniques to minimize the likelihood of injuries. Early detection

and intervention significantly reduce the injury count among athletes, thereby extending their career longevity. Utilizing wearable devices such as accelerometers and gyroscopes, athletes' biomechanical data can be analysed alongside physiological measures (e.g., heart rate, sleep patterns) and performance statistics (e.g., endurance, speed, agility) (6). Recognizing patterns and correlations in these data can signal potential harm, and AI can

pinpoint patterns and links that may elude human observation. AI systems can identify risk factors for specific injuries (3). For instance, AI can recognize behaviours that predispose an individual to stress fractures or knee issues. Upon being alerted to potential risks (4), coaches and doctors can implement preventive measures.



Figure 1. Artificial Intelligence (AI) in Sports Medicine: A Comprehensive Overview

AI leverages athlete-specific data to formulate plans aimed at reducing injury risk. The AI algorithms can provide personalized advice to athletes, considering their unique characteristics, training history, and injury risk factors. In this way, AI may recommend adjustments to the training regimen. AI-driven wearable devices can monitor an athlete's movements in real time, during both training and competition (7). AI can oversee data in real time and deliver immediate feedback on form and technique, thereby enabling athletes to avert injury-

prone actions. In the event of abnormalities or an elevated injury risk, the system can monitor athletes' biomechanics and alert coaches and medical professionals. These alert systems enable prompt preventive action, such as workload reduction or the introduction of suitable therapies.

AI TO IMPROVE TRAINING STRATEGIES

AI-enabled data analysis is emerging as a powerful tool to transform training strategies. AI algorithms can create

exhaustive profiles of athletes' physiological and biomechanical responses by amalgamating data from various sources like wearable devices, training logs, and real-time performance metrics (8). With this wealth of information, practitioners can devise highly individualized and precise training programs, setting accurate durations, intensities, and recovery periods. Consequently, AI-guided training initiatives pave the way for well-tailored training plans, mitigating the risks of under- or overtraining.

AI usage in sports medicine training programs confers numerous benefits. Foremost, AI systems can analyse vast volumes of data in real-time, identifying patterns and connections that could go unnoticed by humans (6). By considering a multitude of parameters simultaneously, such as heart rate, oxygen consumption, muscle activity, and movement tracking, AI algorithms can render a comprehensive picture of an athlete's health. This enables practitioners to fine-tune the intensity and duration of workouts tailored to each athlete (9).

Moreover, AI-powered algorithms can adapt workout programs based on continuous data flow from wearable devices and other performance metrics. Factors impacting exercise tolerance are critical for top-tier performance and also for health outcomes (3). This adaptive strategy facilitates more effective and safer training, as athletes can instantaneously modify the intensity or duration of their exercises. AI systems can also identify early signs of fatigue or insufficient recovery and provide preventive advice to avoid setbacks.

AI-driven training programs allow for a more precise allocation of available resources. By training at the optimal volume and intensity, AI algorithms can enhance performance based on a quantitative analysis of the athlete's training load and recovery ability. This approach helps avert fatigue build-up and injury risk [8]. AI-guided training regimens strike an optimal balance between training stimuli and recovery, thus maximizing an athlete's potential while minimizing the risk of overtraining.

Furthermore, AI systems can learn from extensive data sets and successful experiences (10), enabling them to customize training programs for athletes at various skill levels. This shared knowledge could potentially enhance future training program effectiveness.

Using AI's extensive data analysis and adaptive capabilities, practitioners can construct individualized training programs with optimized intensities, durations, and recovery times. AI-guided training programs have the potential to boost sports and athletic performance by

helping athletes reach their peak potential without risking their health through overtraining or injury.

AI TO ENHANCE REHABILITATION

AI is revolutionizing the approach to rehabilitation and recovery post-injury, a crucial phase in any athlete's journey. AI systems can dynamically tailor rehabilitation programs by analysing data from rehabilitation activities, physiological markers, and athletes' feedback simultaneously (4). Machine learning algorithms facilitate real-time feedback and personalized treatments, continually adapting therapeutic procedures based on an individual's recovery progress. This approach expedites the healing process and minimizes the risk of future injury, enabling athletes to return to competition stronger and more resilient.

The capacity of AI to analyse extensive data from rehabilitation exercises, physiological markers, and patient feedback greatly enhances rehabilitation (5). Machine learning algorithms can decode this data, unearthing patterns, correlations, and trends that may elude human therapists (3). Consequently, these insights allow rehabilitation plans to be adjusted and fine-tuned in real time, reflecting each patient's evolving condition. Real-time feedback constitutes another critical component of AI-based rehabilitation. Through sensors and wearable technology, AI systems can track an athlete's biomechanics, physiology, and movement patterns during rehabilitation programs (8). Instantaneous data collection and analysis of an athlete's form, progress, and technique can bolster improvement and mitigate future injury risks (4).

Personalized therapy is another benefit offered by AI in rehabilitation. AI algorithms can individualize rehabilitation plans considering factors such as injury type, severity, medical history, and treatment response (6). Customized care enhances the likelihood of a successful rehabilitation outcome via more accurate treatments and comprehensive recovery strategies.

AI-aided rehabilitation can accelerate recovery and lower the chances of re-injury. AI systems that continuously adjust therapy procedures based on real-time data [5] and patient progression can optimize the intensity, duration, and types of exercises, thereby promoting efficient healing and avoiding burnout. Athletes, through such personalized rehabilitation, can return to competition in a healthier and more prepared state.

Although AI offers significant potential to reshape the rehabilitation industry, it should serve to complement human experience and clinical judgment rather than

replace it. AI systems can enhance decision-making and offer valuable insights. But they shouldn't overshadow the need for human health professionals to interpret data. AI is required to provide advice, and exercise informed judgment based on human expertise and knowledge. The potential of AI is to adapt rehabilitation programs in real time, provide immediate feedback, and tailor therapies to each patient signals a promising future for sports medicine.

ETHICAL CONSIDERATIONS AND HUMAN EXPERTISE

AI technology offers an extraordinary capacity to bolster sports medicine, contributing significantly to injury prevention, bespoke training, and expedited recovery. Nevertheless, it is critical to underscore that AI's role is supplementary, designed to augment, not replace, the invaluable expertise of sports medicine professionals. As we navigate this nascent technological terrain, it is crucial to address several ethical and practical considerations.

Firstly, we must underscore the paramount importance of Data Privacy. Given that AI operates on extensive health and performance data of athletes, it is incumbent upon us to ensure the absolute security and confidentiality of this information. In the context of sports medicine, the AI systems must be designed and used in a way that safeguards this sensitive data from any potential breaches.

Transparency is the second significant pillar in responsible AI integration. AI's ability to engender beneficial outcomes is contingent on the trust of its end-users. Therefore, ensuring that the logic and rationale behind AI's outputs are explicable and comprehensible to human operators is essential. By promoting transparency, we cultivate confidence in the technology, which allows potential glitches to be identified and rectified promptly, mitigating any adverse impacts.

Thirdly, the issue of Accountability demands serious attention. Irrespective of the support provided by AI, the ultimate responsibility for patient welfare must remain with human experts. Although AI can provide insightful recommendations, human professionals are required to exercise their clinical judgment in the final decision-making process. Consequently, clear mechanisms must be established to manage potential errors or complications arising from AI utilization, ensuring accountability and rectification.

Lastly, it is crucial to articulate AI's Role within the field. While AI exhibits impressive capabilities in detecting patterns, predicting performance, and personalizing

training regimes, it lacks the discernment, empathy, and experience inherent to human professionals. AI should thus be conceptualized as a robust tool designed to enhance human capacity, not to serve as a surrogate for human expertise.

CONCLUSION

AI is paving the way for sports medicine to enter a new phase, transforming the way we prevent injuries, train athletes, and manage rehabilitation. AI's ability to handle huge amounts of data and provide useful insights is changing the game; making treatments more personalized and helping athletes perform at their best. However, it's crucial to use AI ethically, making sure that the personal touch and expertise of sports medicine professionals stay central to taking care of patients.

Using AI wisely can take sports medicine to new area, helping athletes stay healthy, improve their performance, and influencing the future of sports. The knowledge and understanding of sports doctors are keys, and while AI can help them make better decisions and improve their skills, it's important that the human touch remains a central part of sports medicine.

When used ethically, AI can help sports medicine reach new levels of success. The careful use of AI in sports medicine will not only help shape the future of sports but also ensure athletes can perform at their best while maintaining their health and safety. While AI has a lot to offer to sports medicine, it needs to be used responsibly, prioritizing human connections and preserving the valuable knowledge of our sports medicine professionals. Through AI, we have the chance to make big changes in the field and create benefits for athletes, coaches, and the wider sports community.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

AVAILABILITY OF DATA AND MATERIALS

Not applicable

COMPETING INTERESTS

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

FUNDING

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

AUTHORS' CONTRIBUTIONS

N.G: conception and design.

N.G and O.M: analysis and interpretation of the data.

N.G and F.F.R: drafting of the paper.

N.G, F.F.R, O.M and N.L.B: revising it critically for intellectual content.

All authors gave their final approval to the version that will be published.

ACKNOWLEDGEMENTS

The authors would like to express their sincere gratitude to Prof. Tore Bonsaksen for his help in the editorial writing process.

DECLARATION

Not applicable.

REFERENCES

1. Dergaa I, Chamari K, Zmijewski P, Ben Saad H. From human writing to artificial intelligence generated text: examining the prospects and potential threats of ChatGPT in academic writing. *Biol Sport*. 2023;**40**(2):615-622. [doi: 10.5114/biolSport.2023.125623](#) [pmid: 37077800](#)
2. Kaul V, Enslin S, Gross SA. History of artificial intelligence in medicine. *Gastrointest Endosc*. 2020;**92**(4):807-812. [doi: 10.1016/j.gie.2020.06.040](#) [pmid: 32565184](#)
3. Al Kuwaiti A, Nazer K, Al-Reedy A, Al-Shehri S, Al-Muhanna A, Subbarayalu AV, et al. A Review of the Role of Artificial Intelligence in Healthcare. *J Pers Med*. 2023;**13**(6). [doi: 10.3390/jpm13060951](#) [pmid: 37373940](#)
4. Ramkumar PN, Luu BC, Haeberle HS, Karnuta JM, Nwachukwu BU, Williams RJ. Sports Medicine and Artificial Intelligence: A Primer. *Am J Sports Med*. 2022;**50**(4):1166-1174. [doi: 10.1177/03635465211008648](#) [pmid: 33900125](#)
5. Summerton N, Cansdale M. Artificial intelligence and diagnosis in general practice. *Br J Gen Pract*. 2019;**69**(684):324-325. [doi: 10.3399/bjgp19X704165](#) [pmid: 31249070](#)
6. Nahavandi D, Alizadehsani R, Khosravi A, Acharya UR. Application of artificial intelligence in wearable devices: Opportunities and challenges. *Comput Methods Programs Biomed*. 2022;**213**:106541. [doi: 10.1016/j.cmpb.2021.106541](#) [pmid: 34837860](#)
7. Kumar V, Worsley M. Scratch for Sports: Athletic Drills as a Platform for Experiencing, Understanding, and Developing AI-Driven Apps. In: Proceedings of the AAAI Conference on Artificial Intelligence.2023. 16011-16016 p.
8. Chidambaram S, Maheswaran Y, Patel K, Sounderajah V, Hashimoto DA, Seastedt KP, et al. Using Artificial Intelligence-Enhanced Sensing and Wearable Technology in Sports Medicine and Performance Optimisation. *Sensors (Basel)*. 2022;**22**(18). [doi: 10.3390/s22186920](#) [pmid: 36146263](#)
9. Hassan A, Aljawad MS, Mahmoud M. An Artificial Intelligence-Based Model for Performance Prediction of Acid Fracturing in Naturally Fractured Reservoirs. *ACS Omega*. 2021;**6**(21):13654-13670. [doi: 10.1021/acsomega.1c00809](#) [pmid: 34095659](#)
10. Helm JM, Swiergosz AM, Haeberle HS, Karnuta JM, Schaffer JL, Krebs VE, et al. Machine Learning and Artificial Intelligence: Definitions, Applications, and Future Directions. *Curr Rev Musculoskelet Med*. 2020;**13**(1):69-76. [doi: 10.1007/s12178-020-09600-8](#) [pmid: 31983042](#)