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The Application of Artificial Intelligence in Medical Diagnostics: Implications for Sports Medicine

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Abstract

This review paper examines the burgeoning role of Artificial Intelligence (AI) in medicine, particularly in diagnostics and sports medicine, by enhancing accuracy, efficiency, and personalization in patient care. With 25 years of development, AI technologies, including machine learning, deep learning, natural language processing, and computer vision, are making significant strides in interpreting medical data and supporting clinical decision-making. Recent advancements allow AI systems to analyze physiological, biomechanical, and behavioral data, leading to improved injury prevention and performance optimization in athletes. These AI-driven tools can predict injury risks by evaluating training loads, biomechanics, and real-time physiological signals. However, their integration into healthcare raises critical ethical concerns related to data privacy, algorithmic bias, and transparency. Ensuring responsible AI use requires adherence to established medical ethics principles—autonomy, beneficence, nonmaleficence, and justice. As AI continues to reshape healthcare delivery, it is essential to strike a balance between technology and compassionate care. By focusing on ethical considerations and refining AI technologies, the healthcare community can harness AI's full potential while safeguarding patient interests and enhancing outcomes. This transformative journey signifies not just technological advancement, but a commitment to improving human health through informed, ethical practices. The future of AI in medicine hinges on maintaining this delicate equilibrium, ensuring that innovations augment rather than diminish the core values of patient-centric care.

Key words: Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL), Natural Language Processing (NLP), Computer Vision, Medical Diagnostics, Sports Medicine, Injury Prevention, Predictive Analytics, Healthcare Technology

Introduction

The contemporary exploration of artificial intelligence (AI) in medicine spans 25 years. [1] Its significance has surged in recent years, evident in the substantial rise in publications that showcase recent breakthroughs and innovative applications.[2,3] A quick search of "Artificial Intelligence" on PubMed on July 25, 2023 revealed 206,353 results [4] The integration of artificial intelligence (AI) into healthcare systems has catalyzed a transformative shift in medical diagnostics, enabling more precise, efficient, and personalized care. In recent years, AI algorithms—particularly those based on machine learning (ML) and deep learning (DL)—have demonstrated remarkable accuracy in interpreting medical imaging, predicting disease outcomes, and assisting clinicians in decision-making [5] As these technologies continue to mature, their applications are expanding beyond traditional medical domains into specialized fields, including **sports medicine**, where rapid and accurate diagnostics are vital for injury prevention, treatment, and rehabilitation. AI-driven diagnostic tools are increasingly being leveraged to analyze data from wearable sensors, medical imaging, and electronic health records, offering a promising frontier for proactive injury management and performance enhancement [6] Furthermore, AI has the potential to reduce diagnostic errors and inter-observer variability, particularly in interpreting MRI and ultrasound scans frequently used in sports injury assessment [7] However, the application of AI in sports medicine also raises critical questions regarding data privacy, model transparency, and the clinical validation of AI tools. These challenges necessitate a deeper understanding of the implications—both opportunities and limitations—of AI technologies in this fast-evolving field.

AI Technologies in Medical Diagnostics

Artificial Intelligence (AI) encompasses a broad set of technologies designed to simulate human intelligence, including learning, reasoning, and self-correction. In medical diagnostics, AI is primarily implemented through machine learning (ML), deep learning (DL), natural language processing (NLP), and computer vision—each contributing uniquely to the analysis and interpretation of complex medical data. [25]

1. Machine Learning (ML)

Machine learning refers to algorithms that improve their performance as they are exposed to more data. In diagnostics, ML models are widely used to detect patterns in medical records, lab results, and imaging data. [26] For example, ML algorithms can classify disease states, predict disease progression, and support clinical decision-making by analyzing large datasets from electronic health records (EHRs) [8] Supervised learning methods are especially prominent in training models to distinguish between healthy and pathological conditions based on labeled data.

2. Deep Learning (DL)

A subfield of ML, deep learning uses artificial neural networks with multiple layers to process vast amounts of data. DL has been revolutionary in medical image analysis, often outperforming traditional methods in identifying abnormalities in radiographs, MRIs, CT scans, and ultrasounds [9] . Convolutional neural networks (CNNs), for instance, have been successfully applied in detecting lung nodules, fractures, brain lesions, and retinal diseases with high accuracy [10]

3. Natural Language Processing (NLP)

NLP allows AI systems to understand, interpret, and generate human language. In medical diagnostics, NLP is employed to extract meaningful insights from unstructured clinical notes, pathology reports, and research articles. It aids in automating documentation, identifying disease mentions, and flagging diagnostic discrepancies [11] . NLP tools also support clinical decision support systems by summarizing patient histories and suggesting potential diagnoses.

4. Computer Vision

Computer vision, particularly when integrated with DL, enables machines to "see" and interpret visual information from medical imaging. These systems can identify subtle anomalies, quantify anatomical features, and even predict outcomes. AI-driven computer vision is increasingly used in dermatology, radiology, and pathology for tasks such as tumor detection, fracture classification, and histopathological analysis [12] The synergy of these technologies has dramatically improved diagnostic precision and speed, making AI an indispensable asset in modern medicine. As these tools continue to evolve, their integration into clinical workflows is expected to enhance early disease detection, reduce diagnostic errors, and enable more personalized healthcare strategies. [27] AI encompasses a variety of technologies capable of analyzing complex data. Machine learning, a subset of AI, uses algorithms that can improve over time through experience, while deep learning employs neural networks to process large datasets, including medical imaging and electronic health records.[31] The results indicate that major hospitals are, at present, using AI-enabled systems to augment medical staff in patient diagnosis and treatment activities for a wide range of diseases [13]

Medical Imaging:

Artificial Intelligence is poised to significantly transform the field of radiology—more rapidly than many other areas of medicine [14]. AI algorithms have demonstrated high effectiveness in interpreting medical images such as MRI, CT scans, and X-rays, particularly in identifying musculoskeletal injuries and subtle abnormalities that may be overlooked by human radiologists. These tools not only enhance diagnostic accuracy but also help reduce clinician workload. For instance, integrated diagnostic assessments that combine radiological, pathological, endoscopic, ultrasonographic, and biochemical data have shown improved accuracy and efficiency with the support of AI-based systems [15]. Convolutional Neural Networks (CNNs), a type of deep learning model, are commonly trained to detect signs of diseases including cancer, pneumonia, and bone fractures. These models assist radiologists by highlighting regions of interest, thereby streamlining the diagnostic process. A notable example is CheXNet, developed by researchers at Stanford University, which achieved radiologist-level performance in detecting pneumonia from chest X-rays [16]. The enhanced efficiency offered by AI will empower radiologists to focus on more value-added tasks, increasing their visibility to patients and positioning them as essential members of multidisciplinary clinical teams. [22]

Predictive Analytics:

By analyzing historical and real-time data, machine learning models can predict the likelihood of injuries based on an athlete's training load, biomechanics, and physiological parameters. [23,24]

The findings highlight significant advancements in injury prediction accuracy, performance analysis precision, and the customization of training programs through AI and ML. [17] Furthermore AI models trained on electronic health records (EHRs), genetic data, and lifestyle factors can identify individuals at high risk for developing chronic conditions such as: Diabetes, Hypertension, Cardiovascular disease, Cancer. [28]

Google's DeepMind developed an AI system capable of predicting acute kidney injury

(AKI) up to 48 hours before it occurs [18] Predictive algorithms monitor vital signs and lab results to detect early warning signs of sepsis, heart failure, or respiratory failure—triggering alerts for timely intervention. For exaple the **Epic Sepsis Model**, used in many U.S. hospitals, predicts the likelihood of sepsis using real-time data from the hospital's EHR system [19] AI can predict which patients are most at risk of being readmitted within 30 days post-discharge, helping hospitals implement targeted discharge planning and follow-up care. Machine learning models developed by OptumLabs predict readmission rates in heart failure patients with greater accuracy than traditional methods [20] Predictive analytics can identify which patients are most likely to respond to a specific treatment regimen, aiding in personalized medicine approaches. IBM Watson for Oncology suggests personalized treatment plans for cancer patients by analyzing clinical evidence and matching patient profiles to similar cases. AI models analyze behavioral data, social media patterns, and medical records to identify patients at risk for conditions like depression or suicide.
Research has shown that natural language processing (NLP) tools can analyze clinical notes to predict suicide risk in veterans [21]

Enhancing Athlete Performance through AI

Artificial Intelligence (AI) is transforming the realm of sports and athletic performance. By analyzing extensive volumes of physiological, biomechanical, and behavioral data, AI systems equip athletes and coaches with invaluable insights to optimize training, refine techniques, mitigate injuries, and enhance competitive advantages. The integration of AI into sports science promotes a data-driven and personalized approach to human performance enhancement. [29] Machine learning models enable the monitoring of an athlete's workload, recovery rates, and physiological signals, allowing for the creation of personalized training plans that adapt in real-time. This not only improves efficiency but also minimizes the risks associated with overtraining. [30] Predictive analytics within AI can evaluate biomechanical data, fatigue indicators, and training histories to pinpoint athletes who are at a higher risk of injury. This early identification facilitates preventive interventions and tailored rehabilitation protocols.[32] Moreover, AI-powered neurofeedback tools enhance cognitive functions such as reaction time, decision-making, and stress management—crucial components of competitive sports. [33] In their current state, AI technologies can act as supplementary tools in exercise prescription, particularly improving access for individuals who may not afford professional guidance. [34] AI-assisted models utilizing Inertial Measurement Unit (IMU) multivariate time series data effectively predict fatigue and stamina, enabling customized training and timely interventions to prevent overtraining. These models enhance decision-making for both coaches and athletes through real-time performance monitoring and individualized training programs based on unique physiological responses. [35] This innovative approach to sports performance analytics illustrates the transformative potential of data-driven methodologies in optimizing training and improving overall performance outcomes [36]

Ethical Considerations and Challenges

Despite the transformative promise of Artificial Intelligence (AI) in medical diagnostics and healthcare delivery, several critical challenges require careful attention.

Foremost among these are concerns about data privacy and ethical governance, as the collection, processing, and sharing of sensitive personal health information raise complex questions around patient consent, data ownership, and misuse Ensuring data security is essential, particularly in an era where healthcare data is increasingly digitized and vulnerable to breaches. [37] Ethics must remain central in the rapidly evolving landscape of healthcare technology. By adopting best practices, healthcare systems and professionals can responsibly integrate AI and robotics, ensuring patient benefits while upholding the highest ethical standards. The integration of these technologies signifies a major shift, promising enhanced diagnostics, treatments, and healthcare delivery, yet it also presents complex ethical challenges that require careful navigation. [38] Overreliance on artificial intelligence (AI) can undermine compassion and erode trust. Transparency and disclosure of AI-generated content are critical to maintaining integrity. Algorithmic ethics raise concerns about algorithmic bias, responsibility, transparency and explainability, as well as validation and evaluation. Information ethics include data bias, validity, and effectiveness. Biased training data can lead to biased output, and overreliance on ChatGPT can reduce patient adherence and encourage self-diagnosis.[39] Looking towards the future, AI holds immense potential for personalized medicine, advanced drug discovery, and addressing global health crises. By leveraging AI technologies, healthcare delivery can become more efficient, data-driven, and patient-centric. [40] AI offers significant potential to automate most of the manual tasks, ensure service consistency, and improve patient care. [41] Ultimately, the goal is to cultivate clinicians who are not only proficient in leveraging AI technologies but also deeply committed to upholding ethical standards and patient-centered care. This balance is essential for the ethical advancement of AI in medicine, ensuring that technological innovations enhance rather than compromise the quality and integrity of patient care. [42]

Conclusion and Future Directions

Artificial Intelligence (AI) has already begun reshaping the landscape of medicine by enhancing diagnostic accuracy, streamlining clinical workflows, and enabling personalized care. From advanced imaging analysis and predictive analytics to robotic surgery and real-time patient monitoring, AI technologies are facilitating faster, more precise, and often more accessible healthcare services. These developments mark a transformative shift toward data-driven and patient-centered care models that were previously unattainable through traditional methods.AI can revolutionize healthcare delivery, but ethical oversight is crucial in its design, development, and implementation. [43]

Before integrating AI into healthcare, practitioners must consider the four principles of medical ethics: autonomy, beneficence, nonmaleficence, and justice. [44] Ultimately, amid the surge of today's artificial intelligence advancements, it is the human touch that will determine how to effectively harness these models while minimizing risks. [45] In conclusion, AI is poised to become a core pillar of modern medicine. But its continued success relies on maintaining a balance between technological innovation and human-centered care. By prioritizing transparency, inclusivity, and ethical integrity, the medical community can ensure that AI enhances—not replaces—the compassionate, thoughtful practice at the heart of healthcare.

Disclosure:

Author Contributions

Investigation, A.K. and M.B.; resources, A.K., M.F., D.M., B.J., M.D., and M.B.; writing—original draft preparation, A.K., M.F., D.M., and M.B. writing—review and editing, A.K; visualization, B.J.; supervision, M.M and A.K.

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The authors declare no conflict of interest.

References

[1] Coiera EW. Artificial intelligence in medicine: the challenges ahead. J Am Med Inform Assoc. 1996 Nov-Dec;3(6):363-6. doi: 10.1136/jamia.1996.97084510. PMID: 8930853; PMCID: PMC116321.

[2] Mahmoudi T, Mehdizadeh A. Artificial Intelligence in Medicine. J Biomed Phys Eng. 2022 Dec 1;12(6):549-550. doi: 10.31661/jbpe.v0i0.2211-1566. PMID: 36569566; PMCID: PMC9759649.

[3] Pop-Jordanova N. Opportunity to Use Artificial Intelligence in Medicine. Pril (Makedon Akad Nauk Umet Odd Med Nauki). 2024 Jul 15;45(2):5-13. doi: 10.2478/prilozi-2024-0009. PMID: 39008641.

[4] Paulson RJ. Artificial intelligence in medicine: it is neither new, nor frightening. F S Rep. 2023 Aug 9;4(3):239-240. doi: 10.1016/j.xfre.2023.08.004. PMID: 37719090; PMCID: PMC10504549.

[5] Xie Y, Zhai Y, Lu G. Evolution of artificial intelligence in healthcare: a 30-year bibliometric study. Front Med (Lausanne). 2025 Jan 15;11:1505692. doi: 10.3389/fmed.2024.1505692. PMID: 39882522; PMCID: PMC11775008.

[6] Reis FJJ, Alaiti RK, Vallio CS, Hespanhol L. Artificial intelligence and Machine Learning approaches in sports: Concepts, applications, challenges, and future perspectives. Braz J Phys Ther. 2024 May-Jun;28(3):101083. doi: 10.1016/j.bjpt.2024.101083. Epub 2024 May 21. PMID: 38838418; PMCID: PMC11215955.

[7] Lakhani P, Sundaram B. Deep Learning at Chest Radiography: Automated Classification of Pulmonary Tuberculosis by Using Convolutional Neural Networks. Radiology. 2017 Aug;284(2):574-582. doi: 10.1148/radiol.2017162326. Epub 2017 Apr 24. PMID: 28436741.

[8] B. Shickel, P. J. Tighe, A. Bihorac and P. Rashidi, "Deep EHR: A Survey of Recent Advances in Deep Learning Techniques for Electronic Health Record (EHR) Analysis," in *IEEE Journal of Biomedical and Health Informatics*, vol. 22, no. 5, pp. 1589-1604, Sept. 2018, doi: 10.1109/JBHI.2017.2767063.

[9] Litjens G, Kooi T, Bejnordi BE, Setio AAA, Ciompi F, Ghafoorian M, van der Laak JAWM, van Ginneken B, Sánchez CI. A survey on deep learning in medical image analysis. Med Image Anal. 2017 Dec;42:60-88. doi: 10.1016/j.media.2017.07.005. Epub 2017 Jul 26. PMID: 28778026.

[10] Esteva A, Kuprel B, Novoa RA, Ko J, Swetter SM, Blau HM, Thrun S. Dermatologist-level classification of skin cancer with deep neural networks. Nature. 2017 Feb 2;542(7639):115-118. doi: 10.1038/nature21056. Epub 2017 Jan 25. Erratum in: Nature. 2017 Jun 28;546(7660):686. doi: 10.1038/nature22985. PMID: 28117445; PMCID: PMC8382232.

[11] Wang Y, Wang L, Rastegar-Mojarad M, Moon S, Shen F, Afzal N, Liu S, Zeng Y, Mehrabi S, Sohn S, Liu H. Clinical information extraction applications: A literature review. J Biomed Inform. 2018 Jan;77:34-49. doi: 10.1016/j.jbi.2017.11.011. Epub 2017 Nov 21. PMID: 29162496; PMCID: PMC5771858.

[12] Lakhani P, Sundaram B. Deep Learning at Chest Radiography: Automated Classification of Pulmonary Tuberculosis by Using Convolutional Neural Networks. Radiology. 2017 Aug;284(2):574-582. doi: 10.1148/radiol.2017162326. Epub 2017 Apr 24. PMID: 28436741.

[13] Lee D, Yoon SN. Application of Artificial Intelligence-Based Technologies in the Healthcare Industry: Opportunities and Challenges. Int J Environ Res Public Health. 2021 Jan 1;18(1):271. doi: 10.3390/ijerph18010271. PMID: 33401373; PMCID: PMC7795119.

[14]Pesapane F, Codari M, Sardanelli F. Artificial intelligence in medical imaging: threat or opportunity? Radiologists again at the forefront of innovation in medicine. Eur Radiol Exp. 2018 Oct 24;2(1):35. doi: 10.1186/s41747-018-0061-6. PMID: 30353365; PMCID: PMC6199205.

[15] Liu PR, Lu L, Zhang JY, Huo TT, Liu SX, Ye ZW. Application of Artificial Intelligence in Medicine: An Overview. Curr Med Sci. 2021 Dec;41(6):1105-1115. doi: 10.1007/s11596-021-2474-3. Epub 2021 Dec 6. PMID: 34874486; PMCID: PMC8648557.

[16 Rajpurkar P, Irvin J, Ball RL, Zhu K, Yang B, Mehta H, Duan T, Ding D, Bagul A, Langlotz CP, Patel BN, Yeom KW, Shpanskaya K, Blankenberg FG, Seekins J, Amrhein TJ, Mong DA, Halabi SS, Zucker EJ, Ng AY, Lungren MP. Deep learning for chest radiograph diagnosis: A retrospective comparison of the CheXNeXt algorithm to practicing radiologists.

PLoS Med. 2018 Nov 20;15(11):e1002686. doi: 10.1371/journal.pmed.1002686. PMID: 30457988; PMCID: PMC6245676. ,

[17] Reis FJJ, Alaiti RK, Vallio CS, Hespanhol L. Artificial intelligence and Machine Learning approaches in sports: Concepts, applications, challenges, and future perspectives. Braz J Phys Ther. 2024 May-Jun;28(3):101083. doi: 10.1016/j.bjpt.2024.101083. Epub 2024 May 21. PMID: 38838418; PMCID: PMC11215955.

[18] Tomašev N, Glorot X, Rae JW, Zielinski M, Askham H, Saraiva A, Mottram A, Meyer C, Ravuri S, Protsyuk I, Connell A, Hughes CO, Karthikesalingam A, Cornebise J, Montgomery H, Rees G, Laing C, Baker CR, Peterson K, Reeves R, Hassabis D, King D, Suleyman M, Back T, Nielson C, Ledsam JR, Mohamed S. A clinically applicable approach to continuous prediction of future acute kidney injury. Nature. 2019 Aug;572(7767):116-119. doi: 10.1038/s41586-019-1390-1. Epub 2019 Jul 31. PMID: 31367026; PMCID: PMC6722431.

[19] Wynants L, Van Calster B, Collins GS, Riley RD, Heinze G, Schuit E, Bonten MMJ, Dahly DL, Damen JAA, Debray TPA, de Jong VMT, De Vos M, Dhiman P, Haller MC, Harhay MO, Henckaerts L, Heus P, Kammer M, Kreuzberger N, Lohmann A, Luijken K, Ma J, Martin GP, McLernon DJ, Andaur Navarro CL, Reitsma JB, Sergeant JC, Shi C, Skoetz N, Smits LJM, Snell KIE, Sperrin M, Spijker R, Steyerberg EW, Takada T, Tzoulaki I, van Kuijk SMJ, van Bussel B, van der Horst ICC, van Royen FS, Verbakel JY, Wallisch C, Wilkinson J, Wolff R, Hooft L, Moons KGM, van Smeden M. Prediction models for diagnosis and prognosis of covid-19: systematic review and critical appraisal. BMJ. 2020 Apr 7;369:m1328. doi: 10.1136/bmj.m1328. Update in: BMJ. 2021 Feb 3;372:n236. doi: 10.1136/bmj.n236. Erratum in: BMJ. 2020 Jun 3;369:m2204. doi: 10.1136/bmj.m2204. PMID: 32265220; PMCID: PMC7222643.

[20] Rajkomar A, Oren E, Chen K, Dai AM, Hajaj N, Hardt M, Liu PJ, Liu X, Marcus J, Sun M, Sundberg P, Yee H, Zhang K, Zhang Y, Flores G, Duggan GE, Irvine J, Le Q, Litsch K, Mossin A, Tansuwan J, Wang D, Wexler J, Wilson J, Ludwig D, Volchenboum SL, Chou K, Pearson M, Madabushi S, Shah NH, Butte AJ, Howell MD, Cui C, Corrado GS, Dean J. Scalable and accurate deep learning with electronic health records. NPJ Digit Med. 2018 May 8;1:18. doi: 10.1038/s41746-018-0029-1. PMID: 31304302; PMCID: PMC6550175.

[21] McCoy TH, Castro VM, Cagan A, Roberson AM, Kohane IS, Perlis RH. Sentiment Measured in Hospital Discharge Notes Is Associated with Readmission and Mortality Risk: An Electronic Health Record Study. PLoS One. 2015 Aug 24;10(8):e0136341. doi: 10.1371/journal.pone.0136341. PMID: 26302085; PMCID: PMC4547711.

[22] Reis FJJ, Alaiti RK, Vallio CS, Hespanhol L. Artificial intelligence and Machine Learning approaches in sports: Concepts, applications, challenges, and future perspectives. Braz J Phys Ther. 2024 May-Jun;28(3):101083. doi: 10.1016/j.bjpt.2024.101083. Epub 2024 May 21. PMID: 38838418; PMCID: PMC11215955.

[23] Denay, Keri L. MD. Stress Fractures. Current Sports Medicine Reports 16(1):p 7-8, 1/2 2017. | DOI: 10.1249/JSR.0000000000000320

[24] M. Melzner, L. Engelhardt, F. Süß, S. Dendorfer, Sensitivity evaluation of a musculoskeletal hand model using Latin hypercube sampling,Gait & Posture,Volume 81, Supplement 1,2020,Page 228,ISSN 0966-6362,doi./10.1016/j.gaitpost.2020.08.008.

[25] Shen D, Wu G, Suk HI. Deep Learning in Medical Image Analysis. Annu Rev Biomed Eng. 2017 Jun 21;19:221-248. doi: 10.1146/annurev-bioeng-071516-044442. Epub 2017 Mar 9. PMID: 28301734; PMCID: PMC5479722.

[26] Filiberto AC, Leeds IL, Loftus TJ. Editorial: Machine Learning in Clinical Decision-Making. Front Digit Health. 2021 Nov 18;3:784495. doi: 10.3389/fdgth.2021.784495. PMID: 34870273; PMCID: PMC8636718.

[27] Razzak MI, Imran M, Xu G. Big data analytics for preventive medicine. Neural Comput Appl. 2020;32(9):4417-4451. doi: 10.1007/s00521-019-04095-y. Epub 2019 Mar 16. PMID: 32205918; PMCID: PMC7088441.

[28] Jiang F, Jiang Y, Zhi H, Dong Y, Li H, Ma S, Wang Y, Dong Q, Shen H, Wang Y. Artificial intelligence in healthcare: past, present and future. Stroke Vasc Neurol. 2017 Jun 21;2(4):230-243. doi: 10.1136/svn-2017-000101. PMID: 29507784; PMCID: PMC5829945.

[29] Bourdon PC, Cardinale M, Murray A, Gastin P, Kellmann M, Varley MC, Gabbett TJ, Coutts AJ, Burgess DJ, Gregson W, Cable NT. Monitoring Athlete Training Loads: Consensus Statement. Int J Sports Physiol Perform. 2017 Apr;12(Suppl 2):S2161-S2170. doi: 10.1123/IJSPP.2017-0208. PMID: 28463642.

[30] Halson SL. Monitoring training load to understand fatigue in athletes. Sports Med. 2014 Nov;44 Suppl 2(Suppl 2):S139-47. doi: 10.1007/s40279-014-0253-z. PMID: 25200666; PMCID: PMC4213373.

[31] LeCun Y, Bengio Y, Hinton G. Deep learning. Nature. 2015 May 28;521(7553):436-44. doi: 10.1038/nature14539. PMID: 26017442.

[32] Windt J, Gabbett TJ. How do training and competition workloads relate to injury? The workload-injury aetiology model. Br J Sports Med. 2017 Mar;51(5):428-435. doi: 10.1136/bjsports-2016-096040. Epub 2016 Jul 14. PMID: 27418321.

[33] Walsh V. Is sport the brain's biggest challenge? Curr Biol. 2014 Sep 22;24(18):R859-R860. doi: 10.1016/j.cub.2014.08.003. PMID: 25247362.

[34] Dergaa I, Saad HB, El Omri A, Glenn JM, Clark CCT, Washif JA, Guelmami N, Hammouda O, Al-Horani RA, Reynoso-Sánchez LF, Romdhani M, Paineiras-Domingos LL, Vancini RL, Taheri M, Mataruna-Dos-Santos LJ, Trabelsi K, Chtourou H, Zghibi M, Eken Ö, Swed S, Aissa MB, Shawki HH, El-Seedi HR, Mujika I, Seiler S, Zmijewski P, Pyne DB, Knechtle B, Asif IM, Drezner JA, Sandbakk Ø, Chamari K. Using artificial intelligence for exercise prescription in personalised health promotion: A critical evaluation of OpenAI's GPT-4 model. Biol Sport. 2024 Mar;41(2):221-241. doi: 10.5114/biolsport.2024.133661. Epub 2023 Dec 13. PMID: 38524814; PMCID: PMC10955739.

[35] Truppa L, Guaitolini M, Garofalo P, Castagna C, Mannini A. Assessment of Biomechanical Response to Fatigue through Wearable Sensors in Semi-Professional Football

Referees. Sensors (Basel). 2020 Dec 24;21(1):66. doi: 10.3390/s21010066. PMID: 33374324; PMCID: PMC7795543.

[36] Biró A, Cuesta-Vargas AI, Szilágyi L. AI-Assisted Fatigue and Stamina Control for Performance Sports on IMU-Generated Multivariate Times Series Datasets. Sensors (Basel). 2023 Dec 26;24(1):132. doi: 10.3390/s24010132. PMID: 38202992; PMCID: PMC10781393.

[37] Morley J, Machado CCV, Burr C, Cowls J, Joshi I, Taddeo M, Floridi L. The ethics of AI in health care: A mapping review. Soc Sci Med. 2020 Sep;260:113172. doi: 10.1016/j.socscimed.2020.113172. Epub 2020 Jul 15. PMID: 32702587.

[38] Elendu C, Amaechi DC, Elendu TC, Jingwa KA, Okoye OK, John Okah M, Ladele JA, Farah AH, Alimi HA. Ethical implications of AI and robotics in healthcare: A review. Medicine (Baltimore). 2023 Dec 15;102(50):e36671. doi: 10.1097/MD.0000000000036671. PMID: 38115340; PMCID: PMC10727550.

[39] Wang C, Liu S, Yang H, Guo J, Wu Y, Liu J. Ethical Considerations of Using ChatGPT in Health Care. J Med Internet Res. 2023 Aug 11;25:e48009. doi: 10.2196/48009. PMID: 37566454; PMCID: PMC10457697.

[40] Maleki Varnosfaderani S, Forouzanfar M. The Role of AI in Hospitals and Clinics: Transforming Healthcare in the 21st Century. Bioengineering (Basel). 2024 Mar 29;11(4):337. doi: 10.3390/bioengineering11040337. PMID: 38671759; PMCID: PMC11047988.

[41] Potočnik J, Foley S, Thomas E. Current and potential applications of artificial intelligence in medical imaging practice: A narrative review. J Med Imaging Radiat Sci. 2023 Jun;54(2):376-385. doi: 10.1016/j.jmir.2023.03.033. Epub 2023 Apr 14. PMID: 37062603.

[42] Lu H, Alhaskawi A, Dong Y, Zou X, Zhou H, Ezzi SHA, Kota VG, Hasan Abdulla Hasan Abdulla M, Abdalbary SA. Patient Autonomy in Medical Education: Navigating Ethical Challenges in the Age of Artificial Intelligence. Inquiry. 2024 Jan-Dec;61:469580241266364. doi: 10.1177/00469580241266364. PMID: 39290068; PMCID: PMC11409288.

[43] Savulescu J, Giubilini A, Vandersluis R, Mishra A. Ethics of artificial intelligence in medicine. Singapore Med J. 2024 Mar 1;65(3):150-158. doi: 10.4103/singaporemedj.SMJ-2023-279. Epub 2024 Mar 26. PMID: 38527299; PMCID: PMC7615805.

[44]Farhud DD, Zokaei S. Ethical Issues of Artificial Intelligence in Medicine and Healthcare. Iran J Public Health. 2021 Nov;50(11):i-v. doi: 10.18502/ijph.v50i11.7600. PMID: 35223619; PMCID: PMC8826344.

[45] Kantor J. ChatGPT, large language models, and artificial intelligence in medicine and health care: A primer for clinicians and researchers. JAAD Int. 2023 Jul 29;13:168-169. doi: 10.1016/j.jdin.2023.07.011. PMID: 37823044; PMCID: PMC10562174.