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THE IMPACT OF ARTIFICIAL INTELLIGENCE ON PHYSIOLOGY AND MEDICINE: A COMPREHENSIVE REVIEW

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ABSTRACT

Artificial intelligence (AI) has garnered significant attention for its potential to revolutionize the fields of Physiology and Medicine. This comprehensive review explores the current landscape of AI applications in healthcare, focusing on its role in medical education, clinical practice, and research. We begin by defining AI and tracing its evolution, highlighting the technological advancements that have propelled its growth in recent years. Through a narrative review of the literature published between 2013 and 2023, we examine the impact of AI on various aspects of Physiology and Medicine. Specifically, we explore the use of AI in predicting and managing severe sepsis, monitoring blood pressure, and analyzing pathological breath phenomena in asthma patients. Additionally, we investigate the integration of AI with wearable technologies to enhance sports medicine and performance optimization. Furthermore, we discuss the application of AI-driven virtual patient simulations in medical education, emphasizing the role of immersive technologies such as virtual reality (VR) and augmented reality (AR). The review concludes with a discussion on the opportunities and challenges associated with AI in healthcare. While AI holds immense potential to improve patient outcomes and streamline healthcare delivery, several concerns, including ethical considerations and regulatory issues, must be addressed. Overall, this review underscores the importance of understanding AI technology for medical professionals and emphasizes the need for evidence-based practices in implementing AI solutions in healthcare.

INTRODUCTION

Artificial intelligence (AI) utilizes computers and machines to replicate human problem-solving and decision-making abilities. It is defined as "a field of science and engineering concerned with the computational understanding of what is commonly referred to as intelligent behavior, and with the creation of artifacts that exhibit such behavior"[1]. Despite its roots dating back more than six decades, significant progress has been achieved in the first two decades of the twenty-first century. This progress can be attributed to advancements in computer technology, machine learning algorithms, the emergence of general-purpose computing on graphics processing units, increased availability of big data, and the proliferation of cloud computing, among other factors [2]. Artificial intelligence holds immense potential in comprehending human physiology and finding various applications in healthcare and medical research.

Artificial intelligence emerged as a significant field within computer science with its formal introduction at the Dartmouth Conference in 1956. Over the years, it has evolved to become one of the foremost technologies globally. Its current definition is somewhat nebulous, often characterized by its capacity to emulate human cognitive functions, including perception, decision-making, and action, commonly summarized as the ability to "mimic the human brain." In essence, AI entails harnessing machines to replicate and augment human intelligence, enabling them to perform tasks such as listening, seeing, speaking, thinking, and making decisions akin to humans.[3-6]

METHODS

A narrative review of the literature published over the last 10 years (2013-2023) was done by searching using the Pubmed, Google scholar and Cochrane Databases using the search terms Artificial Intelligence, Physiology, Medical Education. Out of the 136 articles only a few relevant articles were selected for analysis and discussion to emphasize the importance of Artificial Intelligence in Physiology. Ethical approval was not necessary because this study is a narrative review of the literature and does not involve primary data, such as data collection or analyses of individual patients.

DISCUSSION

Artificial intelligence has demonstrated promise in predicting the onset of severe sepsis in critically ill children by utilizing physiological markers. In a study conducted by Kamleshwaran et al., data from 493 critically ill children admitted to a tertiary care pediatric intensive care unit (PICU) over eight months were analyzed. Among them, 20 developed severe sepsis. The study examined continuous minute-by-minute physiological data up to 24 hours prior to the onset of severe sepsis, using an electronic screening algorithm's alert time stamp as a reference point. The analysis identified physiomarkers, including standard deviation of heart rate, systolic and diastolic blood pressure, and symbolic transition probabilities of these variables, which distinguished severe sepsis patients from controls (other PICU patients not meeting severe sepsis criteria). Various machine learning techniques, including logistic regression, random forests, and deep Convolutional Neural Network methods, were employed to develop predictive models. Results from the analysis windows of 2–8 hours and 8–24 hours prior to the alert showed differences in specificity and sensitivity across the models. Logistic regression, random forests, and Convolutional Neural Network methods exhibited varying performance metrics across the two analysis windows, with specificity and sensitivity values ranging accordingly.[7]

Blood pressure serves as a crucial indicator of cardiovascular health in clinical practice, necessitating regular monitoring for early detection and treatment of various blood pressure disorders. Traditional measurement methods present inherent limitations, including undetermined measurement time, discomfort during continuous monitoring, and complexity of the process. The emergence of wearable devices capable of continuous blood pressure monitoring offers promising solutions to these challenges.

In a study by Zhang et al., an efficient blood pressure prediction method based on support vector machine regression (SVR) was proposed to address the need for continuous monitoring. The SVR algorithm was compared with two classical machine learning methods, linear regression (LinearR) and backpropagation neural network (BP), using six evaluation metrics: accuracy, pass rate, mean absolute percentage error (MAPE), mean absolute error (MAE), R-squared coefficient of determination (R2), and Spearman's rank correlation coefficient. Results demonstrated that the SVR model accurately and effectively predicted blood pressure levels.[8]

Hafke-Dys et al. conducted a study to investigate the feasibility of utilizing artificial intelligence (AI) analysis to

determine the severity of pathological breath phenomena in asthmatic patients based on sounds recorded during standard stethoscope auscultation. The findings suggest that the proposed AI approach could serve as a valuable tool for monitoring the respiratory status of asthma patients. It has the capability to differentiate between stable conditions and exacerbations, enabling automated monitoring of asthma.[9] Wearable technologies are small electronic and mobile devices with wireless communication capabilities that can be worn on the body as a part of devices, accessories or clothes. Sensors incorporated within wearable devices enable the collection of a broad spectrum of physiological data that can be processed and analyzed by artificial intelligence (AI) systems. In a review by Chidambaram, S et al which analyzed various studies that used sensors to collect data for a sporting event and subsequently used an AI-based system to process the data with diagnostic, treatment or monitoring intents. The studies were classified according to the stage of an event, including pre-event training to guide performance and predict the possibility of injuries; during events to optimise performance and inform strategies; and in diagnosing injuries after an event. Based on the included studies, AI techniques to process data from sensors can detect patterns in physiological variables as well as positional and kinematic data to inform how athletes can improve their performance. The authors concluded that AI can improve the way injury prediction models work; increase the diagnostic accuracy of risk stratification systems; provide a reliable method for the continuous monitoring of patient health data; and enhance the quality of the patient's experience. However, at this point, the technology and logistics underlying wearable devices themselves were still at early stages and need further work.[10]

Virtual patients represent interactive computer simulations designed for health professions training and education, replicating real-life clinical scenarios. Programmed with realistic symptoms and responses to student interventions, virtual patients provide dynamic clinical experiences. Learners assume the role of healthcare providers, engaging in information acquisition, suggesting differential diagnoses, devising medical management plans, and following up with patients. These simulations offer varied medical scenarios, presenting students with challenges akin to real-life situations. Interacting with virtual patients allows medical students to hone communication and clinical reasoning skills within an immersive and interactive virtual environment.To enhance learning experiences with virtual patients, immersive technologies such as virtual reality (VR) and augmented reality (AR) can be utilized. VR utilizes software to create three-dimensional simulated environments, often employing head-mounted displays or glasses to immerse users in computer-generated scenarios. In contrast, AR enhances real-world environments by overlaying virtual components onto the user's view of the real world, typically through smartphones or other devices. Integration of VR and AR technologies enables learners to explore complex clinical scenarios in an engaging and realistic manner, thereby enhancing the effectiveness and enjoyment of the learning process.[11-14]

CONCLUSION

Artificial intelligence (A.I.) is poised to have a profound impact on the fields of Physiology and Medicine, as well as on healthcare delivery in the foreseeable future. Despite the limited number of concrete examples demonstrating its medical utility with substantial evidence, the level of hype and attention surrounding A.I. is substantial. The abundance of scientific papers, conference presentations, sensational news headlines, and interpretations of studies necessitates the creation of a concise and visually accessible guide that medical professionals can consult in their day-to-day practice. To this end, it is imperative for Medical Physiologists to grasp the fundamental principles of A.I. technology. This understanding enables them to navigate through the hype, critically evaluate A.I.-based studies and their clinical validity, and recognize both the limitations and potential opportunities offered by A.I. in healthcare. Moreover, any A.I.-based technology intended for use in healthcare must adhere to stringent regulatory standards, demonstrate efficiency, and be supported by robust evidence.

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