Letter to Editor

Artificial Intelligence and Sleep Medicine

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Given the rapid advancement of artificial intelligence (AI), I aim to emphasize the emerging potential of AI in sleep medicine while also addressing the challenges related to its adoption and implementation in clinical settings. AI has significantly enhanced our understanding of sleep patterns, enabling more precise diagnosis and personalized treatment plans. Beyond sleep tracking, AI contributes to telemedicine, smartwatches, and more. Advanced machine learning approaches, including deep learning, exhibit impressive capabilities in detecting sleep disorders. In this letter, I briefly outline the role of AI in sleep medicine, its methodological approaches, advantages, and potential drawbacks. I have also outlined strategies for effective AI use in sleep medicine while acknowledging potential challenges. Dissemination of this information among specialists and researchers in the field may foster informed and strategic integration of AI into sleep medicine.

AI describes the capacity of computational systems to carry out functions typically linked to human cognitive abilities and has become increasingly integrated into everyday activities. Its applications span diverse fields, including health, personalized lifestyle management, education, finance, industry, marketing, and entertainment. The health domain, in particular, has been transformed by the incorporation of AI (1).

Within the health domain, AI has enabled significant progress across various applications, including diagnostic imaging, drug discovery, personalized treatment planning, virtual health assistants, predictive analytics for patient outcomes, remote patient monitoring, robot-assisted surgery, natural language processing techniques applied to electronic health records (EHRs), behavioral health monitoring, and genomic medicine. The accelerated progress of AI in medicine over the past decade has been driven by the availability of large-scale health datasets, improvements in computational power and data storage, and the development of increasingly advanced algorithms supporting AI-based applications (2).

In addressing current challenges and opportunities in global sleep medicine (3), AI has emerged as a valuable contributor. Similar to its impact on other medical fields, AI has advanced several domains in sleep medicine including:

1) Sleep tracking and analysis: AI aids in tracking, analyzing, improving, and preventing sleep-related health issues.

2) Digital health: Sleep-related technologies contribute to the broader field of digital health.

3) Telemedicine platforms: Telemedicine platforms now include sleep-related consultations and remote monitoring of sleep patterns.

4) Wellness and lifestyle management: AI plays a role in wellness and lifestyle management through fitness trackers and smartwatches.

5) Integration with health platforms: Sleep-tracking applications are seamlessly integrated into personal health and fitness platforms (1, 4).

Figure 1 presents a general workflow of AI-based sleep studies, illustrating how raw sleep data are sequentially preprocessed, analyzed, and processed using AI tools to generate clinically relevant results and evaluation outcomes.

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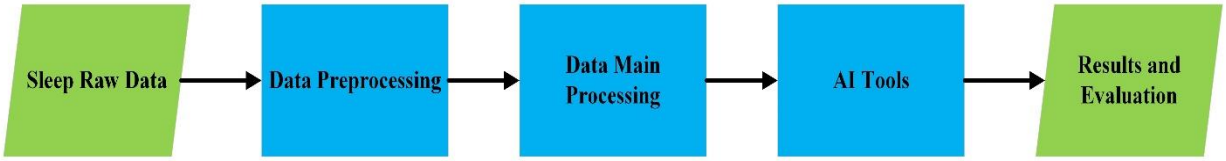

Figure 1. A general block diagram of artificial intelligence (AI)-based sleep studies

Key research-oriented applications of AI in sleep medicine include automated polysomnography (PSG) scoring, sleep disorder diagnosis, elucidation of underlying pathophysiological mechanisms, support for treatment selection, prediction of downstream consequences of sleep disorders, and assessment of sleep health at both individual and population levels. The convergence of advances in physiology, neuroscience, and AI has also enabled exploration of previously unexplored areas of sleep medicine, such as dreaming, as reported in previous studies (5, 6).

Machine learning, a subset of AI, is broadly categorized into supervised, unsupervised, and reinforcement learning, each offering unique capabilities in sleep medicine. Supervised learning is commonly used in decision-support systems, such as co-scoring or analysis of PSG data. Unsupervised learning is applied to data-driven categorization, including the identification of main clusters within population-level sleep data. Reinforcement learning supports adaptive, time-dependent learning by allowing an agent to optimize decision-making through continuous interaction with its environment and feedback provided as rewards or penalties.

Traditional machine learning methods, such as artificial neural networks, have been widely used in sleep medicine. However, with the emergence of deep learning models, there is a growing trend toward adopting these advanced methods. Machine learning, especially when combined with deep learning, has demonstrated remarkable performance in sleep-related applications, with reported accuracies of up to 99% for sleep apnea detection and up to 98% for sleep stage recognition (7). In addition to high performance, the advent of explainable AI has improved the interpretability of AI methods, enabling clinicians with limited AI knowledge to better understand AI-derived results. This capability also allows researchers to connect AI findings to physiological outcomes. Consequently, an increasing number of studies, such as those focusing on sleep disorder detection or sleep scoring, are leveraging AI to harness its capabilities effectively.

Several factors facilitate the application of AI in sleep medicine, primarily the complex, nonlinear, and dynamic nature of physiological recordings. The massive data obtained from biosignal recordings in sleep labs, ambulatory devices such as smartwatches, and consumer sleep technologies further enhance the potential of AI. The widespread availability of such data – commonly referred to as “big data” – has enabled researchers to advance understanding of sleep physiology, enhance the diagnostic accuracy of sleep disorders, predict responses to treatment, identify distinct endotypes, and leverage sleep-related parameters as indicators of future physical and mental health outcomes (2, 8).

To maximize the benefits of AI in sleep medicine, specialists should prioritize multimodal sleep data integration, longitudinal data collection, high-quality annotation and labeling, continuous learning and training, active feedback to AI developers, adaptability and flexibility, interdisciplinary collaboration, clinical expertise, and educating AI peers and developers. Despite the significant opportunities presented by AI, it is essential to acknowledge its limitations and address associated technical and ethical concerns. Technical limitations include issues related to data quality and quantity, explainability, interpretability, generalizability, accuracy, and reliability of AI results in clinical settings. Ethical concerns involve data privacy, bias and fairness, security risks, equitable access, and the potential generation of fake biosignals or data, which could lead to legal and ethical dilemmas or inaccurate diagnoses and treatments.

In this letter, recently published studies were selected to provide insight into AI applications in sleep medicine and to offer fundamental information for future research. In conclusion, while AI should be actively employed in sleep medicine to capitalize on its capabilities, careful consideration and proactive measures are crucial to minimize potential errors, mitigate risks, and address ethical issues.

Conflict of Interests

Author have no conflict of interests.

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References

1. Bandyopadhyay A, Goldstein C. Clinical applications of artificial intelligence in sleep medicine: A sleep clinician's perspective. Sleep Breath 2023; 27: 39-55.
2. Chakraborty C, Bhattacharya M, Pal S, et al. From machine learning to deep learning: Advances of the recent data-driven paradigm shift in medicine and healthcare. Curr Res Biotechnol 2024; 7: 100164.
3. Emami L, Najafi A, Qin H, et al. Current challenges and opportunities in global sleep medicine. In: Clete K, Editor. Encyclopedia of Sleep and Circadian Rhythms. 2nd ed. Amsterdam, Netherlands: Elsevier; 2023. p. 643-81.
4. Watson NF, Goldstein C, Rusk S, et al. How will artificial intelligence advance sleep medicine? In: Kushida CA, Editor. Encyclopedia of Sleep and Circadian Rhythms. 2nd ed. Amsterdam, Netherlands: Elsevier; 2023. p. 43-52.
5. Zanegeneh Soroush M. What Enables Our Brain to Dream? A Bio-Cybernetics View. J Sleep Sci 2023; 7: 51-2.
6. Zanegeneh Soroush M. Deep Learning in Sleep Medicine: Advantages and Drawbacks. J Sleep Sci 2021; 6: 51-2.
7. Xu S, Faust O, Seoni S, et al. A review of automated sleep disorder detection. Comput Biol Med 2022; 150: 106100.
8. Watson NF, Fernandez CR. Artificial intelligence and sleep: Advancing sleep medicine. Sleep Med Rev 2021; 59: 101512.