What Is the Role of AI in Sleep Disorder Assessment?

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Published: June 14, 2016 | AI in Mental Health

DOI: 10.5281/zenodo.17999193

Abstract

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Sleep disorders affect a significant portion of the global population, with estimates suggesting that 30-45% of adults experience sleep-related issues [1]. These conditions, ranging from sleep apnea to insomnia, are linked to severe health complications, including cardiovascular disease, diabetes, and neurocognitive impairment [2]. Traditionally, the diagnosis of sleep disorders has relied on in-laboratory polysomnography (PSG), a comprehensive but costly and labor-intensive process. The logistical challenges and high costs associated with PSG have led to a large number of undiagnosed cases, highlighting a critical gap in healthcare delivery. In recent years, artificial intelligence (AI) has emerged as a transformative technology poised to revolutionize the assessment and management of sleep disorders.

One of the most significant contributions of AI in sleep medicine is the automation of sleep study analysis. The manual scoring of PSG data is a time-consuming task that requires specialized expertise and is prone to inter-scorer variability. AI algorithms, particularly those based on machine learning and deep learning, can analyze vast datasets of physiological signals with remarkable speed and consistency. These automated systems are now used for sleep staging, scoring respiratory events, and identifying other critical biomarkers of sleep pathology. The U.S. Food and Drug Administration (FDA) has already cleared several AI-based auto-scoring software systems, underscoring their clinical validity and potential to enhance the efficiency of sleep labs [1].

The advent of wearable technology has further expanded the reach of AI in sleep medicine. Consumer-grade wearables, such as smartwatches and fitness trackers, equipped with sophisticated sensors, can continuously monitor

physiological parameters like heart rate, respiratory rate, and body movement. When coupled with AI algorithms, these devices can provide valuable insights into a user's sleep patterns and screen for potential sleep disorders. For instance, a recent scoping review found that wearable AI was widely deployed for diagnosing and screening for sleep disorders, with sleep apnea being the most studied condition. The most popular algorithms for this purpose were convolutional neural networks (CNNs), random forests, and support vector machines (SVMs) [3]. This accessibility to long-term, real-world data offers a more holistic view of a patient's sleep health compared to a single night in a sleep lab.

A crucial aspect of integrating AI into clinical practice is ensuring transparency and interpretability. The "black-box" nature of some AI models has been a barrier to their adoption, as clinicians need to understand the rationale behind an AI-generated diagnosis. To address this, researchers are developing "transparent AI" frameworks, such as the Apnea Interact Xplainer (AIX). This system not only provides a highly accurate diagnosis of sleep apnea but also offers a multi-level, expert-logic interpretable visualization of respiratory patterns. This transparency fosters trust and enables a collaborative decision-making process between clinicians and the AI, which is particularly valuable for identifying subtle or atypical presentations of sleep disorders [2].

Looking ahead, the role of AI in sleep disorder assessment is expected to expand beyond diagnosis and screening. AI has the potential to facilitate personalized treatment plans by analyzing individual patient data to predict treatment responses and identify the most effective interventions. For example, AI can help predict adherence to Positive Airway Pressure (PAP) therapy in sleep apnea patients, allowing clinicians to intervene early and improve treatment outcomes [1]. Furthermore, as AI models are trained on increasingly large and diverse datasets, they will become even more adept at identifying novel biomarkers and predicting the long-term health consequences of sleep disorders.

In conclusion, artificial intelligence is rapidly transforming the landscape of sleep medicine. From automating the analysis of complex sleep studies to enabling accessible, home-based screening through wearable devices, AI is addressing many of the long-standing challenges in the field. By providing accurate, efficient, and increasingly interpretable assessments, AI is not only improving the diagnosis of sleep disorders but also paving the way for more personalized and proactive approaches to sleep health. As this technology continues to evolve, it holds the promise of a future where sleep disorders are more easily identified, effectively managed, and ultimately prevented.

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