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EDITORIAL

Rethinking obstructive sleep apnoea: integrating precision medicine and technological advances across the lifespan

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Obstructive sleep apnoea (OSA) has evolved from a traditionally underrecognized sleep disorder to a complex, multisystem disease with profound cardiovascular, metabolic, and neurocognitive implications. The five review articles included in this issue collectively reflect a paradigm shift in our understanding and management of OSA, highlighting the limitations of conventional approaches while emphasizing the emergence of precision medicine, advanced bio signal analysis, and artificial intelligence (AI) as transformative tools in the field.

The review by Giatti et al.[1] explores the concept of co-morbid insomnia and OSA (COMISA), emphasizing the shortcomings of reductionist approaches in sleep medicine. The coexistence of insomnia and OSA is both common and clinically relevant, yet its implications remain insufficiently understood. Importantly, these disorders may interact in ways that are not merely additive, raising questions about their combined impact on cardiovascular risk and systemic outcomes. This perspective challenges conventional frameworks that treat sleep disorders in isolation and underscores the need for integrative, phenotype-oriented models of assessment and management.

Complementing this, the review by Galán-González et al.[2] examines the bidirectional relationship between obesity and OSA, highlighting its central role in disease pathophysiology and treatment. Multiple mechanisms, including upper airway anatomical changes, impaired ventilatory control, and metabolic dysregulation, contribute to the heterogeneity of OSA expression. While weight-loss interventions consistently reduce disease severity and improve cardiometabolic outcomes, their effectiveness varies across populations. Limited representation of females, older adults, and non-obese phenotypes further emphasizes gaps in the literature. Together, these findings reinforce the importance of individualized, phenotype-driven strategies that integrate weight management with established therapies such as continuous positive airway pressure (CPAP).

Building on the theme of early intervention and individualized risk, López-Monzoni et al.[3] highlight the significance of paediatric OSA as a modifiable cardiovascular risk factor. Despite a prevalence of up to 4%, paediatric OSA is often underdiagnosed, yet it contributes to long-term cardiovascular morbidity. The authors describe the mechanisms linking intermittent hypoxia, sympathetic activation, inflammation, and endothelial dysfunction to early vascular damage. Their work reinforces the notion that cardiovascular disease may originate in childhood, positioning paediatric OSA as a crucial target for prevention. Incorporating tools such as ambulatory blood pressure monitoring, echocardiography, and emerging metrics like hypoxic burden represents a meaningful step toward personalized risk stratification and early intervention.

Aligned with this focus on nuanced risk assessment, Labarca et al.[4] challenge the longstanding reliance on the apnoea-hypopnea index (AHI) as the cornerstone of OSA diagnosis and severity classification. While AHI measures event frequency, it fails to capture the complexity and heterogeneity of physiological disturbances

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associated with OSA. The adoption of novel metrics, including hypoxic burden, ventilatory burden, delta heart rate, and pulse arrival time, marks a pivotal step toward more clinically meaningful disease characterization. Hypoxic burden, in particular, emerges as a robust predictor of cardiovascular outcomes and mortality, outperforming traditional indices across multiple cohorts. This shift from frequency-based to impact-based metrics aligns with broader trends toward precision medicine, facilitating the identification of high-risk phenotypes and more targeted therapeutic strategies.

Finally, Boira et al.[5] highlight the transformative potential of AI in sleep medicine. Machine learning and deep learning algorithms are revolutionizing both diagnostics and analytics, from automated scoring of polysomnography to simplified diagnostic tools using single-channel signals or wearable devices. AI also enables cluster analysis to identify distinct OSA phenotypes, advancing the movement toward personalized medicine by allowing treatment strategies tailored to individual patient profiles rather than relying solely on aggregate indices like AHI.

Taken together, these five reviews converge on a central theme: the necessity of moving beyond reductionist models of OSA toward a multidimensional framework that incorporates physiological complexity, individual susceptibility, and technological innovation. The traditional model, centred on AHI and uniform treatment pathways, is increasingly insufficient to capture the heterogeneity of OSA and its systemic consequences. A new paradigm is emerging, integrating advanced bio signals, cardiovascular risk profiling, and AI-driven analytics.

Yet challenges remain. Despite the promise of novel biomarkers such as hypoxic burden, their implementation in routine practice requires standardization, validation across diverse populations, and integration into clinical guidelines. AI, while offering unprecedented opportunities, must overcome concerns related to data quality, interpretability, and regulatory oversight to ensure safe and equitable use. In paediatric populations, longitudinal studies are essential to determine the long-term impact of early interventions on cardiovascular outcomes.

In conclusion, the evolving landscape of OSA research reflects a transition toward precision medicine, driven by advances in bio signal analysis and AI. Integrating these approaches has the potential to transform diagnosis, risk stratification, and management of OSA across the lifespan. Future efforts should focus on bridging the gap between innovation and clinical application, ensuring that these advances translate into improved patient outcomes and more efficient healthcare delivery.

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