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Obstructive Sleep Apnea in Women: Addressing Health Disparities with Advanced Solutions

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Summary

This paper examines the challenges in diagnosing and treating Obstructive Sleep Apnea (OSA) in women. It highlights how OSA, affecting 6-19% of women, often goes undiagnosed due to atypical symptom presentation and limitations in traditional diagnostic methods. Women may present with symptoms of fatigue and insomnia rather than the classic loud snoring and excessive daytime sleepiness seen in men. Traditional home sleep tests cannot identify respiratory events without major drops in blood oxygen levels and are intended for testing patients with high suspicion of moderate to severe OSA, which is often not the case in women. This leads to false negative test results, underdiagnosis, undertreatment, and health disparities.

The paper discusses how Nox's care model addresses these issues by integrating advanced diagnostic technologies, such as the Nox T3s Home Sleep Apnea Testing (HSAT) device, enhanced with BodySleep 2.0, Nox's FDA-cleared artificial intelligence to score arousals and sleep stages based on analysis of Nox RIP belt data, with dedicated care teams and telemedicine services. These innovations allow the detection of OSA with the high level of sensitivity required for effective diagnosis in women. When coupled with continuous and personalized care, these innovations result in improved treatment adoption, adherence, and outcomes, including enhanced health equity, reduced costs, and prevention of associated comorbid conditions.

Introduction

Obstructive Sleep Apnea (OSA) represents a significant yet often overlooked public health challenge, affecting approximately 13-33% of men and 6-19% of women in the general population, although these are likely underestimates.[1] The health consequences of untreated OSA are substantial, ranging from cardiovascular disease and type 2 diabetes to cognitive impairment and increased risk of motor vehicle accidents.[2] Despite these serious implications, women are more likely to be undiagnosed due to gender differences in symptomatology and test results that are often missed in traditional care pathways.

The failure to accurately diagnose OSA in women represents a critical healthcare inequity issue. This gap in diagnosis and subsequent treatment can lead to serious health consequences that add to the economic burden of untreated OSA, estimated in the billions annually in the US alone,[3] underscoring the urgent need for widespread implementation of innovative diagnostic tools, such as those developed by Nox, to ensure equitable healthcare delivery and improved health outcomes for women.

Gender disparities in OSA diagnosis

Differences in symptom presentation

As with many diseases, OSA was first observed in men, and therefore, the defining symptomatology aligns with their typical signs and symptoms: loud snoring, observed apneas, and excessive daytime sleepiness.[4] However, women with OSA are up to 3 times less likely to present with these classic signs/symptoms and often present with different, more subtle symptoms, including insomnia, headaches, mood disturbances, and fatigue.[5,6] In primary care settings, without the guidance of a sleep specialist, these symptoms are often misattributed to other conditions, such as depression, anxiety, or menopause itself, often resulting in underdiagnosis or misdiagnosis.[7]

Physiological differences

During sleep, women with OSA are more likely to experience hypopneas that may not cause significant drops in blood oxygen levels (desaturations) but cause brief interruptions in sleep (cortical arousals), while men are more prone to complete airway obstructions (apneas) and more

prominent hypopneas resulting in desaturations. Physiological factors that may contribute to these differences include[5,6]:

- Women tend to store fat in different areas of the body than men, impacting how airway restrictions (apneas/hypopneas) present.
- Hormonal influences, particularly during menstruation, pregnancy, and menopause, can affect sleep patterns and breathing during sleep. Premenopausal women may be protected by the effects of female sex hormones on the patency of the upper airway. The risk of developing sleep apnea in women increases around menopause.[6]
- Comorbid conditions that are associated with an increased likelihood of OSA (e.g., polycystic ovarian syndrome [PCOS]).

The importance of hypopneas with arousal but without significant oxygen desaturation

Although the American Academy of Sleep Medicine recommends the scoring of hypopneas using its 1A definition, which allows an associated cortical arousal to qualify a hypopnea even without associated significant oxygen desaturation, there is undue emphasis on oxygen desaturation as a marker for a significant obstructive respiratory event by many sleep medicine practitioners. In addition to causing sleep fragmentation and its consequences (excessive daytime sleepiness and cognitive impairment), an arousal has hemodynamic effects (including variations in heart rate and blood pressure) that can have cardiovascular consequences even in the absence of significant hypoxemia.[8–10]

Limitations of traditional diagnostic testing

The process of diagnosing OSA in women involves some gender-specific challenges that often contribute to healthcare disparities if not addressed by expert sleep care and sensitive testing.[11] Traditional diagnostic approaches, particularly home sleep apnea tests (HSATs), are intended for testing patients highly suspected to have moderate to severe OSA; in other words, these tests are best suited for patients who have OSA that is likely to be diagnosed despite the limited sensitivity of the testing. Therefore, these tests are more likely to miss or yield inconclusive results for women due to their physiological differences.[12]

Traditional HSATs are limited by their reliance on oxygen desaturations on pulse oximetry to identify obstructive respiratory events. The high prevalence in women of hypopneas with associated cortical arousals but without significant drops in oxygen saturation[8] markedly limits the diagnostic value of this testing modality and frequently results in false negative or inconclusive results, as well as underestimation of OSA severity.[10]

Health equity consequences

The under-recognition of OSA in women results in significant gender disparities in sleep health care. False negatives due to the use of traditional home sleep apnea testing without subsequent sleep laboratory testing results in under recognition and undertreatment of OSA. A survey of over 8,000 individuals who were diagnosed with or at high risk for OSA found that men were 1.6 times more likely than women to report having sleep laboratory testing.[13] Undiagnosed OSA in women can lead to persistent health consequences and diminished quality of life, including[5,6,14]:

- Insomnia
- Daytime fatigue
- Cognitive impairment/cognitive decline; increased risk of Alzheimer's disease
- Depression and anxiety
- Reduced work performance
- Increased accident risk
- Elevated risk for hypertension, cardiovascular disease, and type 2 diabetes
- Pregnancy complications (e.g., prolonged labor, c-section deliveries, and small infants for gestational age)
- Increased appetite and weight gain
- Decreased ability to fight infections
- Increased mortality

Women who are tested using standard HSATs, which do not include EEG or sophisticated analytical tools to detect cortical arousals, may receive either false negative results or may be referred by more astute physicians to a sleep laboratory for detailed in-lab testing (*polysomnography*) with EEG. This adds considerably more expense and burden, as well as delays in diagnosis and treatment. Without a home sleep test with the sensitivity to reliably detect OSA in women, the diagnosis can be missed or the subsequent need for in-lab polysomnography can complicate the clinical pathway by introducing scarcity of the needed resources with associated long waiting periods and geographic access issues, as well as the inconvenience of having to spend a night at the sleep laboratory.

Nox's state-of-the-art home sleep testing promotes equitable care

As mentioned previously, traditional home sleep apnea testing (HSAT) devices include different measurement methodologies, each with their strengths and weaknesses. The simplest tests rely on signals recorded by a pulse oximeter that records

blood oxygen saturation (SpO_2), pulse, and photoplethysmography (PPG) signals. While these devices are easy for patients to use at home, they have limitations. The readings can be less accurate in people with poor blood supply to the extremities (e.g., women with Raynaud's syndrome) or more skin pigmentation/darker skin tones.[15,16] Certain medications and health conditions that impact blood vessels and heart rate can also reduce their accuracy.[17]

Peripheral Arterial Tone (PAT) technology builds upon PPG technology by measuring pressure fluctuations in the finger using a pneumo-probe. While this method may work better for people with darker skin tones, the signal may still be affected by conditions and medications that impact blood flow and heart rate.[18]

The American Academy of Sleep Medicine (AASM) and the Centers for Medicare and Medicaid Services (CMS) define a Home Sleep Apnea Test (HSAT) as a sleep study that measures airflow, respiratory effort, and blood oxygen saturation.[19,20]

More advanced home testing technologies offered by Nox as a part of the SleepCharge program seek to increase diagnostic sensitivity and address the gender disparities in OSA diagnosis. Nox offers state-of-the-art diagnostics using the Nox T3s Home Sleep Apnea Testing (HSAT) device, enhanced with BodySleep 2.0, Nox's FDA-cleared artificial intelligence to score arousals and sleep stages based on analysis of Nox RIP belt data, for more comprehensive sleep testing that shows clinically acceptable agreement with in-lab polysomnography for AHI ≥15 events/hour.[21] In the subsequent sections, we outline the components of the Nox T3s HSAT with BodySleep that may improve equitable access to testing reliability, accuracy, and sensitivity for women.

Portable and user-friendly devices

Nox's state-of-the-art portable, user-friendly[22] sleep diagnostic devices allow patients to conveniently undergo advanced home sleep apnea testing with PSG-level precision - Conclusive Sleep Apnea Testing - in the comfort of their own homes. This is particularly beneficial for patients who may face barriers to in-lab testing, such as work schedules, caregiving responsibilities, or lack of access to a sleep center. Nox's devices are user-friendly, enabling patients to perform sleep studies independently at home while capturing high-quality data comparable to that recorded in a sleep laboratory.[23,24]

Respiratory Inductance Plethysmography (RIP)

Nox has invested significantly in RIP technology, as it is one of the most reliable and important signals in a sleep recording. RIP measures the expansion and contraction of both the chest and abdomen to monitor breathing patterns. Unlike traditional respiratory effort belts combined with oximetry, Nox RIP can detect subtle changes in breathing associated with arousals but not necessarily accompanied by oxygen desaturation[25], making it especially useful in detecting the more subtle respiratory events commonly seen in women and non-obese patients. This allows more accurate assessment of OSA severity and consequently, better-informed treatment decisions.[26–29]

AI-enhanced diagnostic tools

Nox leads the field by integrating AI algorithms into its sleep diagnostics. Using machine learning, the Nox BodySleep 2.0 analyzes RIP signals for more accurate respiratory event detection with the ability to identify associated arousals and adds sleep stage identification without requiring additional EEG/EOG data. The AI scoring is able to detect wake, non-REM sleep, and REM sleep epochs, helping clinicians to better understand their patients' individual presentation of sleep apnea–promoting equitable OSA care for everyone.[25]

These AI models, trained on diverse datasets, can identify obstructive respiratory events even when oxygen desaturations are insignificant, as often seen in women. These tools also allow for the generation of hypnograms and hypnodensity plots, providing clinicians with insights into sleep stages.[30] This additional information improves overall diagnostic accuracy by ensuring that no critical details are missed.[31]

Simplifying OSA diagnosis and management for women with personalized care and telemedicine

SleepCharge simplifies OSA diagnosis and management for women by combining state-of-the-art, accurate home testing, personalized care, and telemedicine. Traditional sleep care pathways can be burdensome, especially for women facing false negative and inconclusive or inaccurate diagnostics, resulting in delayed treatment and reduced treatment adoption and adherence. SleepCharge addresses these problems by offering additional services, including patient support and telemedicine.

Dedicated care teams ensure continuous support

Unlike traditional care pathways, where patients often have difficulty reaching overbooked sleep specialists and device manufacturers for assistance with their home sleep testing devices, SleepCharge provides dedicated, multidisciplinary care teams to guide patients from OSA screening to long-term management. This personalized support consolidates otherwise fragmented care, a health equity issue that disproportionately affects those juggling multiple roles, such as single working parents, the majority of whom are women. Nox's patient-centered approach–offering continuous assistance with testing, diagnosis, and treatment–improves treatment adherence[32] and ensures comprehensive, uninterrupted care, leading to better outcomes and reduced healthcare disparities.

Telemedicine expands access to equitable care

Integrating telemedicine revolutionizes access to specialized sleep care, overcoming geographical and scheduling barriers for all patients in rural or underserved areas. Remote consultation and interpretation of enhanced home sleep tests allow access to otherwise unavailable expert services as well as superior diagnostic sensitivity, particularly for women whose results can often be false-negative or inconclusive with traditional home testing and further compromised by automated scoring. These are important steps toward addressing healthcare disparities and improving OSA management in women.

Conclusion

Nox's advanced sleep care model, integrating cutting-edge, Conclusive Sleep Apnea Testing enhanced with FDA-approved AI analysis, telemedicine, and gender-sensitive approaches, has the potential to significantly improve health outcomes for women with OSA. This comprehensive approach addresses long-standing disparities in OSA diagnosis and treatment, offering several key benefits:

1. **Early detection and intervention by utilizing testing that is not plagued by false negatives,** preventing the progression of associated chronic conditions
2. **Personalized treatment plans,** associated with improved adherence and outcomes[32]
3. **Reduced healthcare utilization by preventing/improving associated chronic conditions,** resulting in cost savings[32]
4. **Improved quality of life** for women with OSA, enhancing daily functioning, productivity, and overall well-being[33]
5. **Long-term health benefits** include a reduction in major cardiovascular and cerebrovascular events[34] and the potential reduction of Alzheimer's disease risk[35]

By partnering with Nox, healthcare providers can close critical gaps in the diagnosis and treatment of OSA in women—delivering care that is more precise, equitable, and effective. Nox's integrated model of advanced diagnostics, AI-enhanced analysis, and personalized support is a meaningful step forward in addressing long-standing disparities in sleep medicine. Together, we can ensure that women with OSA receive the care they need—improving health outcomes, reducing long-term risks, and elevating standards of care across the board.

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