Gender Disparities in Obesity Hypoventilation Syndrome

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KEYWORDS

• Sleep-disordered breathing • Hypoventilation • Women's health • Postmenopausal women
• Positive airway pressure therapy • Acute hypercapnic respiratory failure • Comorbidities
• Clinical outcomes

KEY POINTS

- Obesity hypoventilation syndrome (OHS) in women is frequently underdiagnosed, with many first presenting in acute hypercapnic respiratory failure.
- Screening for OHS should be considered in obese postmenopausal women with sleep-disordered breathing.
- Women with OHS show a higher burden of complications, including pulmonary hypertension, heart failure, and metabolic comorbidities, requiring gender-sensitive care strategies.
- Despite delayed diagnosis, treatment with noninvasive ventilation (NIV) in OHS results in clinical outcomes comparable between women and men.
- Research on gender disparities in OHS is limited; larger, multiethnic studies are needed to clarify prevalence, presentation, and long-term outcomes.

INTRODUCTION

Sleep-disordered breathing (SDB) encompasses a spectrum of conditions characterized by abnormal breathing patterns during sleep, including snoring, hypopnea (reduced airflow), apnea (complete cessation of airflow), and hypoventilation. SDB includes obstructive sleep apnea (OSA), central sleep apnea, and the most severe form, obesity hypoventilation syndrome (OHS).

The traditional paradigm that sleep-disordered breathing predominantly affects men requires urgent re-examination. While epidemiologic studies consistently report a higher prevalence of OSA in men,[1] emerging evidence suggests women with SDB may experience distinct symptom profiles, diagnostic challenges, and disproportionately severe health trajectories. Recent compelling data demonstrate that women with OSA face substantially higher welfare costs, mortality risk, and health care utilization despite prolonged periods of missed diagnostic opportunities.[2] These findings challenge conventional assumptions about gender patterns in SDB while emphasizing the urgent need for gender-sensitive approaches that include tailored screening strategies and increased awareness of gender-specific differences across the entire SDB spectrum.[3] These observations are particularly relevant for OHS, where gender-specific features have received even less attention in the literature than OSA.

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Abbreviations

ABG	arterial blood gas
ADHF	acute decompensated heart failure
AHI	apnea hypopnea index
AHRF	acute hypercapnic respiratory failure
ATS	American Thoracic Society
BMI	body mass index
BPAP	bilevel positive airway pressure
CI	confidence interval
COPD	chronic obstructive pulmonary disease
CPAP	continuous positive airway pressure
HMV	home mechanical ventilation
ICSD-3-TR	International Classification of Sleep Disorders, Third Edition
ICU	Intensive care unit
LTMV	long-term mechanical ventilation
MPA	medroxyprogesterone acetate
NIV	noninvasive ventilation
NREM	nonrapid eye movement
OHS	obesity hypoventilation syndrome
OR	odds ratio
OSA	obstructive sleep apnea
$PaCO_2$	partial pressure of carbon dioxide
PAP	positive airway pressure
PSG	polysomnogram
SDB	sleep-disordered breathing

Consider the projected epidemiologic shift: a recent prospective modeling study projects that OSA cases in the United States will reach 76.6 million by 2050, with women experiencing a 65.4% relative increase in prevalence, resulting in an estimated 30.4 million cases.[4] This represents a larger proportional increase than expected in men, suggesting that the historical male predominance of OSA may diminish substantially over the coming decades.

According to the International Classification of Sleep Disorders, Third Edition (ICSD-3-TR), OHS is defined by the presence of daytime hypercapnia (partial pressure of carbon dioxide, $PaCO_2$ > 45 mm Hg) in an individual with obesity (body mass index [BMI] $\geq$30 kg/m^2), in the absence of other causes of hypoventilation such as pulmonary or neuromuscular disorders.[5] Although OSA remains the most prevalent type of SDB, approximately 90% of patients with OHS also have concomitant OSA, with roughly 73% of OHS patients demonstrating severe OSA.[6] Conversely, OHS occurs in 8% to 20% of OSA patients referred to sleep medicine clinics.[7] The remaining 10% of patients with OHS experience sleep-related hypoventilation with mild or no OSA. Compared with OSA alone, OHS is associated with significantly higher morbidity, mortality, and greater impairment in quality of life.[8,9]

Intriguingly, although male sex represents a well-established risk factor for OSA, this pattern does not extend to OHS. Multiple studies across diverse geographic regions and ethnic populations report higher OHS prevalence in women, particularly postmenopausal women.[10–13] This female predominance becomes even more pronounced when considering that women with OHS frequently present later in their disease course, often during acute hypercapnic respiratory failure (AHRF) episodes.

This gap potentially contributes to systematic underdiagnosis, especially among women who may present with atypical symptom patterns. Emerging evidence suggests that hormonal factors, particularly the influence of menopause, may contribute to the pathophysiological differences observed between men and women with OHS.[10,14] Does the delayed recognition of OHS in women reflect health care system bias and inadequate awareness, or do pathophysiological changes following menopause actually increase women's vulnerability to this condition?

Recognizing gender differences in OHS becomes essential for identifying high-risk populations and enabling early diagnosis and targeted interventions. Such efforts may help mitigate the substantial health burden associated with untreated OHS, which demonstrates higher mortality rates and greater health care resource utilization compared with eucapnic OSA.[15,16] As obesity prevalence continues rising globally and the projected women's burden of OSA increases dramatically over the next 3 decades, understanding gender disparities in OHS assumes critical importance for preventing the evolution from simple OSA to life-threatening OHS.

This article examines gender disparities in OHS, synthesizing evidence on female predominance, delayed diagnosis patterns, and sex-specific pathophysiological mechanisms to inform more equitable clinical approaches.

SEARCH METHODOLOGY

The authors conducted a comprehensive narrative literature search following established guidelines.[17] PubMed/MEDLINE was searched using ("obesity hypoventilation syndrome" or "OHS" or "Pickwickian syndrome") and ("gender" or "sex" or "women" or "female" or "male" or "sex differences" or "gender differences"). The search yielded 2,049 records (1964–2025), including 560 gender-related studies (27.3%) and 50 specifically addressing OHS and gender aspects. The authors included peer-reviewed articles, clinical studies, systematic reviews, and observational studies

published in English, focusing on human studies addressing gender aspects of OHS. Case reports with fewer than 5 patients were excluded.

EPIDEMIOLOGY OF OBESITY HYPOVENTILATION SYNDROME

The exact prevalence of OHS remains uncertain, although it is estimated to affect approximately 0.15% to 0.3% of adults in the United States.[18] With the global rise in obesity, the actual burden of OHS is likely to be underestimated. Indeed, the prevalence of OHS increases with the severity of obesity, reaching approximately 27% among individuals with a BMI over 40 kg/m^2, and up to 50% in those with a BMI exceeding 50 kg/m^2.[19,20] OHS has been reported in 8% to 20% of patients referred to sleep medicine clinics.[21,22] However, OHS is often underdiagnosed and may be misclassified as chronic obstructive pulmonary disease (COPD) or acute decompensated heart failure (ADHF), particularly in clinical settings where SDB is not routinely evaluated.[23,24] Therefore, the reported prevalence in sleep clinics likely reflects only those who were correctly referred and assessed for OHS. If all patients with suspected OHS underwent a systematic evaluation, the actual prevalence in these populations could be even higher.

Gender-Based Prevalence and Geographic Variation in Obesity Hypoventilation Syndrome

In 1962, Drachman and Gumnit reported one of the earliest cases linking obesity, hypoventilation, and OSA symptoms, which are now recognized as defining characteristics of OHS.[25] The 57-year-old woman's sleepiness worsened with weight gain and improved significantly after a 35-pound weight loss.[25] Notably, this foundational case involved a woman, underscoring that women have been affected by OHS since its earliest clinical recognition.

Subsequent studies from various geographic regions have reported a female predominance in OHS (**Table 1**). Early observations from a sleep clinic cohort first suggested that the traditional male predominance in SDB might not extend to OHS. In Saudi Arabia, among 1,973 patients referred to the sleep medicine center with SDB, OHS was diagnosed in 144 (7.3%) patients.[14] The prevalence was significantly higher in women (15.6%) than in men (4.5%) (P<.001), reflecting a 3.5-fold difference, with women accounting for 67% of all OHS cases. Additionally, women were significantly older than men at the time of diagnosis (mean age 61.5 vs 49.1 years, P<.001), suggesting possible underdiagnosis or delayed assessment in women.[14]

Another important observation from this study was the markedly higher prevalence of OHS among postmenopausal women (21%) compared with premenopausal women (5.3%).[14] Interestingly, even when comparing postmenopausal women with age-matched men, the prevalence of OHS remained 4 times higher in women. This finding was observed despite no significant differences in BMI or apnea hypopnea index (AHI), supporting the potential contribution of hormonal changes during menopause to the development of OHS.[10,14] Unfortunately, other studies did not report the menopausal status of women with OHS.

Another recent study from Martinique, a French Caribbean territory with a predominantly Afro-Caribbean population, reported a higher prevalence of OHS among women, who comprised 79.7% of the cohort (114 out of 143).[26] The mean age at diagnosis was 67.3 plus or minus 15.5 years, supporting reports of delayed diagnosis and treatment initiation.[26] However, the exclusion of men with a smoking history exceeding 15 pack-years, to avoid confounding with COPD, may have contributed to the observed female predominance in this study.

In India, a recent study involving 674 patients referred for sleep studies because of suspected OSA reported an OHS prevalence of 5.8%.[12] Although men comprised most of the overall cohort (63.2%), female sex was strongly associated with OHS. Among patients with OHS, 78.1% were women, and on univariate analysis, the odds of OHS were nearly 7 times higher in women than in men (odds ratio [OR] = 6.9, 95% CI: 2.9–16.3; P<.001). Multivariate logistic regression confirmed this association, with female sex remaining an independent predictor (OR = 4.1).[12]

The underdiagnosis of OHS in women and their presentation at a more advanced stage has been reported in a nationwide Swedish study.[27] In a cohort of 1,527 patients with OHS who initiated long-term home mechanical ventilation, women represented 47.4% of the population and were generally older, had a higher BMI, and exhibited more pronounced hypoxemia and hypercapnia than men.[27] Notably, patients with OHS receiving continuous positive airway pressure (CPAP) therapy were not represented in this registry, which may have influenced the reported prevalence and sex distribution.

In contrast, a study from Edinburgh, United Kingdom, reported a lower prevalence of OHS among women compared with men.[28] Among 99

Table 1
Female representation and key characteristics across obesity hypoventilation syndrome cohorts (2012–2025)

First Author and Year	Country/ Region	% Female in OHS Cohort	Study Population	Key Characteristics
Carrillo et al,[52] 2012	Spain	77%	AHRF on NIV; OHS cohort (n = 173)	Female-predominant cohort
Marik et al,[24] 2013	USA	77%	Hospitalized patients with AHRF and multisystem organ dysfunction related to obesity (n = 61)	6 times admission over 2 y; 75% were mistakenly diagnosed and treated for COPD/asthma
BaHammam et al,[14] 2016	Saudi Arabia	67%	Sleep-clinic referrals (n = 144)	Postmenopausal predominance
Palm et al,[27] 2016	Sweden	47.4%	National LTMV registry (n = 1,527)	Women were older and had more severe disease
Masa et al,[13] 2020	Spain	80%	Ambulatory OHS without severe OSA (n = 98)	Female-predominant; no sex-stratified outcomes reported
Arish et al,[28] 2022	United Kingdom	44%	Sleep-clinic cohort (n = 99)	Younger cohort, no age difference by gender
Msaad et al,[23] 2022	Tunisia	75%	Hospitalized patients with AHRF (n = 44)	Over two-thirds of patients were misdiagnosed with asthma/COPD exacerbation and/or heart failure
Agossou et al,[26] 2023	Martinique	79.7%	Hospitalized patients, predominantly of African-Caribbean descent. (n = 143)	High obesity, low smoking rates
Nowalk et al,[11] 2025	Spain	58%	Hospitalized acute hypercapnic respiratory failure (n = 1162)	Women were older than men
Nowalk et al,[11] 2025	Spain	64%	Ambulatory Pickwick cohort (n = 300)	Women were older and had a higher BMI
Isaac et al,[12] 2025	India	78.1%	Sleep-clinic referrals (n = 32)	The odds of OHS were nearly seven times higher in women than in men

Abbreviations: AHRF, acute hypercapnic respiratory failure; BMI, body mass index; COPD, chronic obstructive pulmonary disease; LTMV, long-term mechanical ventilation; *n*, sample size; NIV, non-invasive ventilation; OHS, obesity hypoventilation syndrome.

patients, 44 were women (44%). The mean age at diagnosis was 54.7 years (53.9 years for men and 55.8 years for women).[28] The younger age of the cohort may explain the lower proportion of women compared with studies from Saudi Arabia, Martinique, and India, and may support the hypothesis that postmenopausal women are more frequently affected by OHS. In summary, many studies from different geographic areas and varied ethnic groups reported a higher prevalence of OHS among women, particularly in postmenopausal and older women.

POTENTIAL PATHOPHYSIOLOGICAL FACTORS BEHIND FEMALE VULNERABILITY TO OBESITY HYPOVENTILATION SYNDROME

Is the late diagnosis of OHS among women because of gender bias in referral and lack of awareness in the health care system, or could it be related to pathophysiological factors that begin after menopause, or both? Several explanations for the increased prevalence of OHS among postmenopausal women have been reported in the literature. The main factors discussed include the roles of progesterone, leptin, and thyroid hormones.

Progesterone is considered a respiratory stimulant that increases alveolar ventilation, augments hypercapnic and hypoxic ventilatory responses, and lowers the $PaCO_2$.[10,29,30] In addition, progesterone enhances upper airway muscle tone, acting as a dilator.[31] The increased prevalence of OSA among postmenopausal women has been attributed, at least partially, to the withdrawal of progesterone. Going with that, a placebo-controlled, double-masked, parallel-group trial compared the effect of medroxyprogesterone acetate (MPA) versus placebo after discontinuation of CPAP therapy in women with OSA.[32] Women receiving MPA had significantly higher nocturnal oxygen saturation and lower $PaCO_2$ compared with those on placebo.[32] Interestingly, carbon dioxide levels were even lower than during CPAP use.[32] Taken together, the substantial overlap of OHS with OSA and the withdrawal effect of progesterone may help explain the higher prevalence of OHS among postmenopausal women.

A second theory involves leptin, a hormone secreted by adipocytes that regulates appetite. Experimental animal studies have demonstrated a significant effect of leptin on ventilatory function and respiratory response to hypercapnia, as well as its role in maintaining upper airway patency.[33,34] Obese women have been found to have leptin levels nearly twice as high as men.[35] Furthermore, obese patients with hypercapnia demonstrate higher leptin levels than those with normal $PaCO_2$.[36] Thus, the combination of higher circulating leptin levels in women and chronic hypercapnia may reflect increased leptin resistance, resulting in central hypoventilation and contributing to the higher prevalence of OHS among women.

The third potential explanation points to the higher prevalence of clinical and subclinical hypothyroidism among women with OHS compared with men.[37,38] Indeed, hypothyroidism may impair the hypoxic and hypercapnic ventilatory response, resulting in hypoventilation. Future studies are needed to clarify the role of thyroid hormones in the development of hypercapnia among patients with OHS. **Fig. 1** illustrates the proposed pathophysiological factors behind female vulnerability to OHS.

CLINICAL PRESENTATION AND DIAGNOSTIC FEATURES BY GENDER

Women with OHS are often diagnosed at an older age and tend to present with more advanced disease and additional comorbidities than men. The older age at presentation among women may reflect either delayed diagnosis because of under-recognition and limited health care access, or the natural emergence of symptoms at a later stage of life. However, the authors consider the latter possibility less likely given that women with OHS demonstrate higher rates of cardiometabolic comorbidities and more frequently present with AHRF, patterns consistent with delayed rather than age-appropriate diagnosis. This delayed recognition may be result from overlapping clinical features with other conditions or limited awareness of OHS within the health care system. Therefore, diagnosing OHS among women requires a high index of suspicion to ensure early identification and timely initiation of appropriate treatment.

Patients with OHS may present with nonspecific symptoms, such as orthopnea and exertional dyspnea, in addition to the classic features of OSA and signs of associated comorbidities, such as cor pulmonale or pulmonary hypertension. In general, individuals with OHS tend to have greater hypersomnolence, morning headaches, dyspnea, and higher BMI compared to patients with OSA alone.[39]

Interestingly, women with OSA tend to report atypical symptoms compared with men. Rather than the classic manifestations of loud snoring, witnessed apneas, and gasping for air, women more frequently experience daytime fatigue, morning headaches, insomnia, and mood disturbances.[40] However, in patients with OHS, symptom profiles appear more similar between genders despite the age difference at diagnosis.[14] Both women and men with OHS generally report comparable rates of excessive daytime sleepiness, snoring, witnessed apneas, and other hallmark features of SDB.[14,28]

It is essential to highlight that a substantial proportion of women with OHS first present with AHRF, yet many are misdiagnosed or insufficiently evaluated for OHS.[14,24,27,41] In 1 study of 144 patients with confirmed OHS (66.7% women), 42% were admitted with AHRF before their OHS diagnosis was established.[21] Another study reported 44 cases of OHS admitted with AHRF, 75% of whom were women,[23] and none had a prior diagnosis of OHS. Notably, many patients had a history of previous admissions to the intensive care unit (ICU) or pulmonology departments, yet their OHS remained unrecognized.[23] These findings underscore a persistent lack of awareness of OHS in the health care system, which contributes to delayed diagnosis and missed opportunities for early identification and appropriate referral, particularly in women presenting with AHRF.

Arterial Blood Gas Profiles in Women and Men with Obesity Hypoventilation Syndrome

The American Thoracic Society (ATS) recommends that arterial blood gas (ABG) analysis be

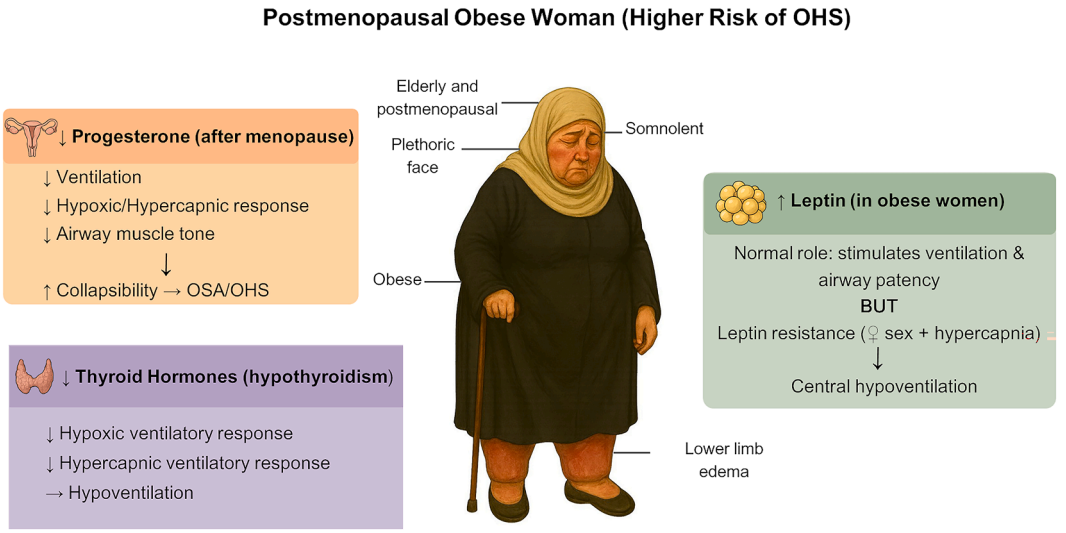

Fig. 1. Pathophysiological Factors Contributing to Female Vulnerability to OHS. This schematic illustrates the complex interplay of hormonal, metabolic, and physiologic factors that increase OHS risk in postmenopausal women. Postmenopausal progesterone decline reduces ventilatory drive and airway muscle tone, while hypothyroidism further impairs respiratory responses, and leptin resistance despite elevated levels leads to central hypoventilation. This multifactorial pathophysiology explains why postmenopausal obese women represent the highest-risk demographic for developing OHS. (*Courtesy of* Alanoud Alsamel.)

performed to confirm the presence of awake hypercapnia in patients with a strong clinical suspicion of OHS.[42] However, in cases where obtaining an ABG is difficult, venous blood samples may serve as a practical alternative for assessing pH, $PaCO_2$, and bicarbonate levels. Mokhlesi and colleagues demonstrated that a venous bicarbonate level exceeding 27 mEq/L in obese individuals had a sensitivity and specificity of 92% and 50%, respectively, for predicting OHS.[43] Conversely, a level below 27 mEq/L had a negative predictive value of 97% for excluding OHS diagnosis.[43] Based on these findings, the ATS issued a conditional recommendation supporting the use of serum bicarbonate less than 27 mEq/L as a screening tool to help rule out OHS in obese patients with OSA, particularly when clinical suspicion for OHS is not very high.[42]

However, a recent study examining over 93,000 patients revealed important sex differences in baseline bicarbonate levels, with men having significantly higher mean values (25.2 mmol/L) than women (24.4 mmol/L), particularly before age 50.[44] This finding suggests that the current universal bicarbonate threshold of 27 mEq/L may have differential screening accuracy between sexes, potentially leading to under-recognition of OHS in women who naturally have lower baseline bicarbonate levels. Although women with OHS are often diagnosed at an older age than men, suggesting a more advanced disease stage at presentation, findings from ABG analyses across studies have varied (**Table 2**).

In the ambulatory setting, data from the 2 Pickwick randomized controlled trials in Spain (n = 300; women: 192 [64%]) showed that women were significantly older and had higher BMI than men.[11,13,45] At baseline, they also had slightly higher bicarbonate levels (30.0 [28.0–32.0] vs 28.9 [27.8–31.2] mmol/L; P=.031), although $PaCO_2$ and PaO_2 were similar between sexes.[11,13,45] In contrast, a large international hospitalized cohort assembled for the 2019 ATS OHS guideline (n = 1,162; 58% women), which included patients admitted with AHRF, revealed significantly higher baseline $PaCO_2$ in women than men (64 mm Hg [IQR 54–77] vs 57.8 mm Hg [IQR 50.6–65.6]; P<.001), supporting reports that women tend to present at a more advanced stage of the disease.[11,46]

As previously discussed, a Swedish study found that women were older and heavier at the initiation of long-term mechanical ventilation (LTMV).[27] These women also exhibited more pronounced gas exchange abnormalities, including lower PaO_2 (57.0 ± 11.3 vs 59.3 ± 12.0; P=.001), higher $PaCO_2$ (54.0 ± 9.8 vs 51.8 ± 9.8; P=.0004), and greater base excess (6.9 ± 4.1 vs 5.8 ± 4.7 mmol/L; P<.001) compared with men.[27] Although both sexes demonstrated significant improvements in ABG parameters after 1 year of LTMV, no persistent sex-based differences were observed at follow-up, indicating comparable treatment response.[27]

Table 2
Sex-stratified arterial blood gas values in obesity hypoventilation syndrome cohorts (women vs men)

Study	Country	Age (Years)	pH (Women)	pH (Men)	$PaCO_2$ mm Hg (Women)	$PaCO_2$ mm Hg (Men)	PaO_2 mm Hg (Women)	PaO_2 mm Hg (Men)	HCO_3 Mmol/L (Women)	HCO_3 Mmol/L (Men)
BaHammam et al,[14] 2016	Saudi Arabia	W: 61.5 M: 49.1	7.38±0.08	7.38±0.05	56.1±11.8	57.6±14.7	60.1±13.6	62.9±12.2	33.2±6.0	32.5±6.6
Palm et al,[27] 2016	Sweden	W: 64.4 M: 60.1	Not reported	Not reported	54.0±9.8 *P* = .0004	51.8±9.8	57.0±11.3 *P* = .0001	59.3±12.0	6.9±4.1 BE p<0.001	5.8±4.7 BE
BaHammam et al,[37] 2020	Saudi Arabia	W: 60.6 M: 45.9	7.4±0.1	7.4±0.1	53.6±9.1 *P* =.037	52.5±9.8	64.7±17.0 *P* =.047	69.6±21.8	31.5±5.4 *P* = .007	30.2±6.3
Arish et al,[28] 2022	United Kingdom	W: 55.6 M: 53.9	Not reported	Not reported	55.48±6.64	58.05±12.5 p=<.001	58.02±12.2	56.9±13.3	31.85±3.6	31.65±4.4
Nowalk et al,[11] 2025	Spain	W: 68 M: 57	7.40 (7.39–7.43) *P* =.045	7.39 (7.38–7.42)	49.8 (47.2–53.0)	49.0 (47.9–51.5)	62.9 (56.5–70.0)	61.0 (56.3–68.0)	30.0 (28.0–32.0) *P* = .031	28.9 (27.8–31.2)

Note: Comparisons are women versus men within each cohort; *P* values are shown only where statistically significant (2-sided *P*<.05) per the original study analyses; nonsignificant comparisons are not displayed.

Abbreviations: ABG, arterial blood gas; BE, base excess; HCO_3^-, bicarbonate; IQR, interquartile range; M, men; *n*, sample size; OHS, obesity hypoventilation syndrome; $PaCO_2$, arterial partial pressure of carbon dioxide; PaO_2, arterial partial pressure of oxygen; pH, hydrogen ion concentration; SD, standard deviation; W, women.

In the earlier-mentioned Saudi cohort, women were also older at diagnosis, but no significant differences in baseline ABG values were found.[14] Conversely, a separate Saudi study reported significantly worse blood gases in women, with more severe hypercapnia, hypoxemia, and higher bicarbonate levels.[37] The discrepancy in findings between the 2 studies may be attributed to the significantly higher BMI observed in women compared with men in the second cohort, a difference not observed in the first study. This supports the concept that more severe obesity in women may contribute to greater hypercapnia and overall OHS severity at the time of diagnosis.[11,27]

Interestingly, a United Kingdom-based study showed the opposite pattern; men had significantly higher $PaCO_2$ levels than women (58.05 ± 12.5 vs 55.48 ± 6.64 mm Hg; $P<.001$).[28] However, women in this cohort were notably younger than those in other studies, which may partly explain the discrepancy in blood gas findings compared with other populations.[28]

In summary, some available evidence suggests that women with OHS tend to present with more severe gas exchange abnormalities, particularly hypercapnia and compensatory bicarbonate retention, than men (see **Table 2**). This is often accompanied by older age and a higher BMI at the time of diagnosis, reflecting a more advanced stage of the disease. Although some studies have found no significant sex-based differences or even milder findings in women, these may reflect younger or earlier diagnosed cohorts. Overall, the evidence highlights the importance of early recognition and targeted screening in women to reduce diagnostic delays and prevent progression to advanced respiratory failure.

Polysomnographic Differences Between Women and Men with Obesity Hypoventilation Syndrome

Given the previously shown trend of late OHS presentation in women and their diagnosis at an older age, it has been questioned whether they exhibit worse sleep study parameters than men. Nevertheless, polysomnogram (PSG) results have been mixed (**Table 3**). In the Pickwick randomized controlled trials, for example, women were older and more obese than men. However, they had a significantly lower apnea-hypopnea index (median 32.4 compared with 69.8 events per hour in men), less hypoxia, and a lower arousal index compared with men.[11,13,45] The duration of nonrapid eye movement (NREM) stage 3 was significantly longer in women. Women reported worse sleep quality, as measured by the Functional Outcomes of Sleep Questionnaire.[11,13,45] Similarly, in the Saudi cohort, where women were significantly older than men, PSG showed a significantly lower AHI in women than in men (median 56.9 vs 81 events per hour). Moreover, poor sleep efficiency and increased wakefulness after sleep onset were more common in women.[14] A consistent finding of poorer sleep efficiency in women was replicated in another larger Saudi cohort, with no significant variations between sexes in other polysomnographic results.[37] Taken together, women with OHS may have poorer sleep efficiency despite showing milder respiratory parameters in PSG (see **Table 3**). This could be caused by hormonal factors, age-related changes in sleep architecture, and a higher prevalence of comorbidities. Studies have shown that even though women with OHS are often older than men, they tend to exhibit lower AHI values.[11,14] Conversely, in the UK cohort, it was reported that younger women had higher AHI values than their male counterparts.[28] Indeed, variations in polysomnographic results might arise from a unique pathophysiological pattern in women, which warrants conducting age-stratified studies in larger groups from diverse ethnic and geographic backgrounds and adopting standardized polysomnographic reporting.

GENDER DIFFERENCES IN COMORBIDITIES AND COMPLICATIONS OF OBESITY HYPOVENTILATION SYNDROME

The female predominance in OHS is not limited to increased prevalence among postmenopausal women but extends to the comorbidities and complications that may contribute to worse outcomes. Studies from Spain and Saudi Arabia have reported a higher prevalence of diabetes mellitus and hypertension among ambulatory women with OHS,[11,14] despite similar BMI between men and women in the Saudi cohort.[14] In addition to these findings, the Saudi study also reported that clinical and subclinical hypothyroidism were more common in women with OHS than in men, supporting the proposed role of hypothyroidism in the pathophysiology of OHS.[14] Notably, a logistic regression model in a subsequent study identified female sex as the only significant predictor of clinical hypothyroidism in patients with OHS (OR: 2.801 [1.386–5.662], $P=.004$).[37] Moreover, among patients with OHS and clinical hypothyroidism, 81% were women, and these women were younger than their euthyroid counterparts (56.6 versus 60.6 years), suggesting that thyroid dysfunction may accelerate the development of OHS in susceptible women.[37] Similarly, a study from India also reported a significant association between hypothyroidism and

Table 3
Sex differences in polysomnographic metrics among patients with obesity hypoventilation syndrome

Study	Country	Sample Size	Sleep Efficiency (%)	AHI (Events/hr)	ODI (Events/hr)	Time SpO2 <90%	Arousal Index	Key Findings
BaHammam et al,[14] 2016	Saudi Arabia	144 patients (96 women, 48 men)	Women: 63.3 (45.7–80.5 Men: 76.7 (62.5–86) *P* = .002	Women: 56.9 (22.3–96.9) Men: 81 (40.3–111.8) *P* = .043	Women: 41 (13–82.6) Men: 44 (25.2–89.5) p = NS	Women: 91.3 (41.3–100) min Men: 85 (53.5–100) min p = NS	Women: 49.6 (28.2–97.5) Men: 78.1 (37.3–104.8) p = NS	Women have significantly poorer sleep efficiency
BaHammam et al,[37] 2020	Saudi Arabia	231 patients (140 women, 91 men)	Women: 61.7±22.4 Men: 68.5±20.6 *P* = .024	Women: 59.8±44.6 Men: 71.0±43.8 p = NS	Women: 43.5 ± 40 Men: 55.2 ± 45.5 p = NS	Women: 41.1 ± 40.2 Men: 41.4 ± 38.7 p = NS	Women: 60.4 ± 40.4 Men: 69 ± 42 p = NS	Consistent finding of poorer sleep efficiency in women
Arish et al,[28] 2022	United Kingdom	99 patients (44 women, 55 men)	Not reported	Women: 64.72±50 Men: 61.59±40 *P* = .03	Not reported	Not reported	Not reported	No significant gender differences (younger cohort)
Nowalk et al,[11] 2025	Spain	300 ambulatory patients (192 women, 108 men)	Not reported	Women: 32.4 (17.9–69.3) Men: 69.8 (36.4–94.9) *P*<.001	Women: 40.6 (18.0–74.5) Men: 70.1 (32.4–93.2) *P*<.001	Women: 75.9 (43.9–95.5) Men: 75.0 (49.8,93.0) p = NS	Women: 32.7 (20.4–58.5) Men: 59.5 (28.0–84.7) *P*<.001	Lower AHI and ODI, and arousal index in women

Abbreviations: AHI, apnea–hypopnea index; IQR, interquartile range; n, sample size; NS, not significant; ODI, oxygen desaturation index; OHS, obesity hypoventilation syndrome; PSG, polysomnography; SD, standard deviation; SpO_2, peripheral oxyhemoglobin saturation.

OHS in the univariate analysis (odds ratio 2.2; *P*=.04), with 80% of patients with OHS and hypothyroidism being women.[12]

Cardiovascular comorbidities also exhibit prominent sex differences. Almeneessier and colleagues reported that pulmonary hypertension affected 71% of women compared with 62% of men with OHS, with severe pulmonary hypertension (systolic pulmonary artery pressure >70 mm Hg) present in 28.6% of women versus 14.3% of men.[47] Of note, 84.2% of patients with severe pulmonary hypertension were women.[47] These findings underscore the importance of routine assessment for pulmonary hypertension in all women with OHS.

It is important to note that the Pickwick trial reported significantly worse right ventricular function in women with OHS compared with men, as reflected by a higher right ventricular performance index (Tei index).[11] Therefore, despite similar pulmonary artery pressures reported in the Pickwick trial, subclinical right ventricular dysfunction may be more prominent in women. The clinician should be aware of these comorbidities and complications and include their assessments in the routine evaluation for all patients with OHS. Indeed, additional studies are needed to explore the sex-related differences in complications and comorbidities of OHS and to determine their clinical impact.

GENDER DIFFERENCES IN MANAGEMENT AND OUTCOMES AMONG PATIENTS WITH OBESITY HYPOTENSION SYNDROME

Therapeutic Approaches and Acute Management

Weight loss remains essential for all patients with OHS, although PAP should not be delayed. Initial therapeutic management approaches are similar for both sexes. The ATS recommends CPAP as first-line therapy for stable ambulatory OHS with severe OSA (AHI $\geq$30), as outcomes are comparable to BPAP.[42] However, women constitute the majority of patients with OHS and no or mild-to-moderate OSA, who typically require bilevel positive airway pressure (BPAP) therapy.[11,13] For hospitalized patients with AHRF, NIV initiation follows the same protocols regardless of sex, with close monitoring until hypercapnia correction.

The population-based DISCOVERY study confirmed that home mechanical ventilation (HMV) initiation significantly reduces hospitalization rates in OHS patients regardless of sex, with women comprising 47% of the 2,445-patient cohort.[48] Importantly, acute and elective HMV initiation showed similar long-term benefits, with hospitalization rates decreasing from 84% to 54% within 1 year (*P*<.05), emphasizing that treatment timing and effectiveness remain comparable between men and women.

Clinical Outcomes and Survival Data

Women with OHS are less likely to receive PAP in the acute setting, and therapy initiation in ambulatory cohorts is often delayed.[11,27] This observation has raised concern about worse clinical outcomes in women, but the current evidence is limited. The Swedish study reported a 5-year survival rate of 59.3% (95% confidence interval [CI], 54.2%–64.0%) in women with OHS on LTMV, compared with 68.2% in men (95% CI, 63.6%–72.3%).[27] Nevertheless, after adjusting for age at LTMV initiation, no significant gender difference in mortality was observed.[27] In contrast, a French study found better survival rates in women; however, after adjusting for confounders, no gender difference persisted.[49]

Post hoc analyses of stable ambulatory patients with OHS from the 2 Pickwick randomized controlled trials revealed notable gender disparities.[11,13,45] In the unadjusted analysis, women had a higher rate of emergency department visits compared with men (72.9% vs 48.1%; *P*<.001), and the median time from study enrollment to the first emergency department visit was approximately 9 months shorter in women.[11] Women also had a higher rate of hospitalization (54.7% vs 45.4%; *P*=.153), although no difference in all-cause mortality was observed.[11] Importantly, after full adjustment, no significant gender differences were found in the composite outcomes of emergency department visits, hospitalizations, or mortality.[11] Among patients with OHS admitted for AHRF, women were prescribed PAP therapy less frequently at discharge, despite having worse baseline hypercapnia compared with men.[11] In unadjusted analyses, hospitalized women demonstrated higher mortality at 3, 6, and 12 months after discharge. However, after adjustment for age, gender itself was not associated with mortality. Instead, baseline $paCO_2$, older age, and discharge without PAP were the main predictors of 12-month mortality.[11] A significant interaction between gender and age was identified, suggesting that age modifies the relationship between gender and mortality, potentially explaining the higher observed mortality in women.[11]

Positive Airway Pressure Adherence

The adherence to PAP therapy represents a significant concern among patients with OHS, regardless of gender. A randomized controlled clinical trial among patients with OHS without severe OSA (The Pickwick randomized controlled trial) showed that median NIV adherence was 3.68 hours

per night, and nearly half of the patients abandoned NIV.[13] Importantly, no significant gender differences in NIV adherence patterns were observed, despite 77.1% of those in the NIV group being women, reflecting the strong female predominance of this phenotype rather than indicating that women were less adherent.[13] The high dropout rate (49% overall) was similarly distributed between sexes, suggesting that treatment tolerance challenges affect men and women equally in this OHS phenotype. Relevantly, post hoc analysis of this randomized controlled trial revealed that patients in the high-NIV-adherence subgroup experienced fewer emergency department visits, a longer time to first hospital admission, and lower mortality rates compared with those in the low-adherence subgroup or the control group across both sexes.[13]

Another study from Saudi Arabia highlighted overall suboptimal long-term adherence among patients with OHS and severe OSA.[50] At 12-month follow-up, 49.3% of the women and 33.3% of the men were still using PAP therapy in an acceptable way (good adherence + partial adherence).[50] Female sex was a significant predictor of good adherence at 1-month follow-up in univariate analysis, although this effect was diminished in multivariable models.[50] Adherence at 1 and 6 months was independently associated with good adherence after 1 year, underscoring the importance of close early follow-up and structured support strategies to optimize PAP adherence, particularly among women.[50]

Weight Loss Interventions

The valuable effect of weight loss should not be overlooked while treating OHS. In a retrospective study of 1,134 patients undergoing bariatric surgery, 16.5% met the OHS criteria.[51] At 1 year, 69% of patients with OHS who discontinued PAP therapy 6 months or more after surgery maintained resolution of hypercapnia ($PaCO_2$ < 45 mm Hg).[51] Importantly, significant reductions in $PaCO_2$ were observed only when total weight loss exceeded approximately 20%.[51] This aligns with the ATS recommendation to achieve sustained weight loss of 25% to 30% of body weight for the resolution of OHS.[42] However, there were no significant differences between men and women in rates of hypercapnia resolution, suggesting that both genders benefit comparably from bariatric surgery in terms of OHS resolution when sufficient weight loss is achieved.[51]

In summary, current evidence does not support an independent gender effect on long-term survival once appropriate therapy is initiated, emphasizing the critical importance of timely PAP initiation in patients with OHS. Further large-scale, gender-stratified longitudinal studies are needed to clarify potential differences in treatment response and long-term outcomes.

SUMMARY

Women, particularly older women, have a higher prevalence of OHS in ambulatory and hospitalized settings. A substantial proportion present with AHRF; nevertheless, OHS is less likely to be evaluated or adequately treated in women. Compared with men, women with OHS appear to have higher rates of complications and comorbidities. Gender differences in PSG metrics and arterial blood gases warrant further study to confirm reports of poorer sleep efficiency and greater hypercapnia in women. NIV yields clinical outcomes that are broadly comparable between sexes. As obesity and OSA prevalence continue to rise, the burden of OHS will likely increase. Clarifying gender differences in prevalence, clinical presentation, diagnostic pathways, treatment response, and long-term prognosis is essential to mitigate this burden. Large, longitudinal, multiregion studies across diverse ethnic groups are needed to inform and refine evaluation and treatment guidelines.

CLINICS CARE POINTS

- Obese women presenting with acute hypercapnic respiratory failure, in the absence of other causes of hypoventilation, should be properly evaluated for OHS, particularly those who are postmenopausal.
- In obese patients with SDB and low clinical suspicion for OHS, serum bicarbonate ≥27 mmol/L can be used as a screening tool, especially in women.
- Women with OHS should undergo routine evaluation for complications, particularly pulmonary hypertension and right and left ventricular dysfunction, and other cardiometabolic comorbidities, including diabetes, hypertension, and hypothyroidism, which occur more frequently in women with OHS.
- PAP therapy requires proper titration and early initiation, with follow-up including arterial blood gases, PAP device downloads, and patient-reported improvement. Initial PAP therapy approaches are similar between genders.
- Weight loss should be encouraged in all OHS patients, with referral to structured obesity management programs when available. Both men and women benefit equally from bariatric surgery when sufficient weight loss (>20%) is achieved.

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