

Systematic Review

Prevalence of Obstructive Sleep Apnea in Patients With Polycystic Ovary Syndrome: A Systematic Review and Meta-Analysis

Marco La Verde^{1,*}, Maria Maddalena Marrapodi^{2,3}, Luigi Della Corte⁴, Antonietta Petillo¹, Mario Fordellone⁵, Hande Uzuncubuk⁶, Silvia Piccolo⁷, Giulia Maria Nicoletti⁸, Giuseppe Minervini^{9,*}

¹Department of Woman, Child and General and Specialized Surgery, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

²Pediatric Unit, Department of Woman, Child and General and Specialized Surgery, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

³Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technical Sciences (SIMATS), Saveetha University, 600077 Chennai, India

⁴Department of Neuroscience, Reproductive Sciences and Dentistry, School of Medicine, University of Naples Federico II, 80131 Naples, Italy

⁵Medical Statistics Unit, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

⁶Department of Orthodontics, Faculty of Dentistry, Trakya University, 22030 Edirne, Turkiye

⁷Department of Biomedicine and Prevention, University of Rome “Tor Vergata”, 00100 Rome, Italy

⁸Oral Surgery Unit, Multidisciplinary Department of Medical-Surgical and Odontostomatological Specialties, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

⁹Multidisciplinary Department of Medical-Surgical and Odontostomatological Specialties, University of Campania “Luigi Vanvitelli”, 80138 Naples, Italy

*Correspondence: marco.laverde@unicampania.it (Marco La Verde); giuseppe.minervini@unicampania.it (Giuseppe Minervini)

Academic Editor: John Alcolado

Submitted: 27 August 2025 Revised: 21 October 2025 Accepted: 29 October 2025 Published: 28 June 2026

Abstract

Aims/Background: Obstructive sleep apnea (OSA) and polycystic ovary syndrome (PCOS) share pathogenic pathways. Our review and meta-analysis estimated OSA prevalence in PCOS patients. **Methods:** Systematic search of four databases was performed: MEDLINE, Scopus, EMBASE, Cochrane Central Register of Controlled Trials from inception until 1 March 2024. Grey literature was explored via Google Scholar. The following keywords were adopted: “obstructive sleep apnea”, “OSA”, “sleep-disordered breathing”, and “polycystic ovary syndrome”. OSA was diagnosed through polysomnography. Observed heterogeneity was evaluated using both Cochran’s Q test ($p < 0.10$) and the I^2 statistic. A random-effects model was applied when significant heterogeneity was detected, with the between-study variance (τ^2) estimated using the DerSimonian-Laird method. **Results:** We included 16 studies in the qualitative analysis and 13 in the quantitative analysis, comprising a total of 230,293 patients, including 148,378 in the control group and 81,915 in the PCOS group. Under the common effect model, the OSA pooled risk ratio in the PCOS group was 2.53 (95% confidence interval [CI]: 2.19–2.92), and 3.55 (95% CI: 1.98–6.37) under the random-effects model. Individual risk ratio ranged between 1.50–25.58. Significant heterogeneity was observed ($I^2 = 73.8\%$, $\tau^2 = 0.4605$, $p = 0.0004$), suggesting potential publication bias based on funnel plot analysis. **Conclusion:** High prevalence of OSA was evidenced in PCOS women. These findings highlighted a significant association between these two conditions and the need for targeted screening or management in these high-risk patients. Further study to investigate these bidirectional relationships is needed. **Systematic Review Registration:** PROSPERO (CRD42024524008).

Keywords: polycystic ovary syndrome; prevalence; obstructive sleep apnea; polysomnography; sleep disorders; metabolic syndrome; insulin resistance

1. Introduction

Polycystic ovary syndrome (PCOS) is a common endocrine disease [1,2]. PCOS carries several health risks and commonly presents with anovulation and androgen excess [3]. PCOS represent a cause of anovulatory infertility and presents a high prevalence in patients with metabolic syndrome or diabetes [4]. PCOS prevalence varies between regions based on race and ethnicity, with significant sub-regional variations of 2–26% [5]. This difference may be related to differential diagnostic criteria of PCOS, heterogeneity in sampling, socioeconomic levels, medical care, and other clinical differences like obesity prevalence [6]. Hispanic women with PCOS present a higher incidence

of hyperandrogenaemia and metabolic syndrome than non-Hispanic women with PCOS [7]. Obesity is a frequent PCOS comorbidity [8]. Evidence also suggests that the syndrome’s severity and clinical manifestations correlate with increased body weight [8]. Different researchers explored the relationship between PCOS and obstructive sleep apnea (OSA), and these two conditions shared risk factors like obesity and metabolic syndrome [9]. OSA leads to intermittent hypoxemia [10]. Several studies explored the relationship between OSA and cardiovascular, metabolic, and gynecologic disease [11]. Currently, the therapeutic approach to OSA is based on continuous positive airway pressure (CPAP) [12]. However, the positive outcomes are



related to patient compliance [13]. CPAP efficiency is limited by low adherence of the patients [13]. Another therapeutic approach is based on oral devices that are less invasive [14]. OSA has more prevalence among males. However, recent data revealed that the female populations present an equal incidence, especially with women affected by PCOS [15]. The bidirectional relationship between PCOS and OSA is an emerging topic. Hormonal and metabolic disturbances associated with the characteristics of PCOS predispose the patients to develop OSA [16]. At the same time, sleep problems and hypoxia associated with OSA may further accentuate the PCOS symptoms [10]. PCOS shows insulin resistance, increased levels of leptin, and even obesity [17]. These conditions also characterize the OSA comorbidities and impact future gestational outcomes [8,18]. Previous reviews and meta-analyses explored OSA incidence in women with PCOS and during the pregnancy [15,19]. Those reviews evidenced an elevated incidence of OSA in PCOS group [15]. Subsequent studies have focused on insulin resistance, obesity, and androgen excess as available means to link these two conditions [8]. However, the relation between these two conditions remains complex, and the studies presented a pronounced variation in the methods and populations examined, which showed different conclusions. We aim to estimate OSA prevalence in patients affected by PCOS and, secondary, to summarise novel research on this clinical relationship.

2. Methods

This meta-analysis followed the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) [20]. The PRISMA checklist is shown in **Supplementary Table 1**. The systematic review was registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (CRD42024524008, <https://www.crd.york.ac.uk/PROSPERO/view/CRD42024524008>).

2.1 Search Strategy

A systematic review of the following databases was performed: MEDLINE (through PubMed, <https://pubmed.ncbi.nlm.nih.gov/>), Scopus (<https://www.scopus.com/>), EMBASE (<https://www.embase.com/search/quick>), and the Cochrane Central Register of Controlled Trials (CENTRAL, <https://www.cochranelibrary.com/search>), from inception until 1 March, 2024. We adopted different keywords related with the obstructive sleep apnea, sleep disordered breathing and polycystic ovary syndrome (**Supplementary Table 2**). We additionally screened grey literature, via Google Scholar, and abstracts of national and international conferences. We also reviewed included studies and related articles from references or other papers. There was no restriction on language and geographical location of the study. We excluded the commentaries, letters to the editors, editorials, reviews and meta-analysis (Fig. 1).

2.2 Study Selection

2.2.1 Inclusion and Exclusion Criteria

We evaluated the studies that include patients affected by PCOS. Our PICOS (population, intervention, control, outcome, and study designs) was: “In adult women with PCOS, how confident is the prevalence of OSA compared to adult women without PCOS?”. We sought to clarify their relationship and explore potential mechanisms and shared risk factors. The PICOS question was: P—population: adult or adolescent patients diagnosed with PCOS; I—intervention: analyses of OSA presence as confirmed with overnight polysomnography with apnea-hypopnea index (AHI) ≥ 5 or respiratory disturbance index (RDI) ≥ 5 ; C—control: adult or adolescent patients without PCOS; O—outcome: Risk and prevalence of OSA as confirmed with overnight polysomnography; S—study designs: different analytic studies (cross-sectional, cohort, case-control, clinical trial) assessing the OSA and the association with PCOS. Two authors (AP and MLV) independently carried out systematic data extraction according to the included abstracts. The authors reviewed the full texts and extracted the relevant data related to study details and their outcomes of interest. When necessary, consensus was reached with the third author (LDC). Full texts of the selected abstracts were retrieved, and this was part of the data screening procedure which needed title emergence, abstracts, obtaining and reshuffling for rescreening to meet inclusion criteria (Fig. 1).

2.2.2 Data Extraction

The data analysis and graphical renderings were achieved with STATA version 14.1 (StataCorp, College Station, TX, USA). The data extracted were: demographic information (first authors and year), characteristics of the sample (age, body mass index [BMI], AHI), study-specific parameters (study type, diagnostic criteria, assessment of OSA, diagnostic criteria for OSA), number of subject (PCOS/control) and the number of subjects with OSA (PCOS/control). Characteristics of the trials and the extracted data were both described in tables (Table 1, Ref. [21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36]; Table 2, Ref. [21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36]).

2.2.3 Quality Assessment

Two authors (MLV and AP) independently assessed the risk of bias. The third author (LDC) resolved the disagreement via discussion and consensus. We used the Risk of Bias Assessment tool for Non-randomized Studies (RoBANS) to assess risk of bias. Because most studies were observational (cohort or case-control), we used RoBANS. We rated the domains as follows: selection bias, confounding bias, measurement bias (exposure and outcome), loss to follow-up bias, and reporting bias.

Table 1. Characteristics of the studies on polycystic ovary syndrome (PCOS) and the risk of obstructive sleep apnea (OSA), which were included in the meta-analysis.

First author	Year	Country	Diagnostic criteria for PCOS	Assessment of OSA	Diagnostic criteria for OSA	Study type
Vgontzas [31]	2001	USA	CA+HA+PCO	NP	AHI ≥ 10 with symptoms	Case-control study
Fogel [24]	2001	USA	CA+HA	NP	AHI > 5 with symptoms	Case-control study
Vgontzas [32]	2006	USA	CA+HA+PCO	NP	NS	Cross-sectional study
Tasali [30]	2008	USA	CA+HA	NP	AHI ≥ 5	Case-control study
Gopal [35]	2002	USA	Not specified	NP	RDI ≥ 5 with symptoms	Cross-sectional study
Chatterjee [34]	2014	India	2 of the following three criteria: CA+HA+PCO	NP	RDI ≥ 5 with symptoms or RDI > 15	Cross-sectional study
Tock [36]	2014	Brazil	Any 2 of the following three: CA+HA+PCO	NP	AHI ≥ 5	Cross-sectional study
Yang [33]	2009	Taiwan	CA+HA+PCO	NP	AHI ≥ 5	Case-control study
De Sousa [21]	2010	Germany	CA+HA	NP	NS	Case-control study
De Sousa [22]	2011	Germany	CA+HA	NP	NS	Comparative cross-sectional study
De Sousa [23]	2012	Germany	CA+HA	NP	NS	Prospective longitudinal study
Nandalike [28]	2012	USA	CA+HA	NP	AHI > 5	Case-control study
Suri [29]	2016	India	CA+HA+PCO	NP	RDI ≥ 5 with symptoms or RDI > 15 with or without symptoms	Case-control study
Lin [27]	2017	Taiwan	CA+HA	NP	NS	Cohort study
Kumarendran [26]	2019	UK	CA+HA+PCO	NP	NS	Population-based retrospective cohort study
Hachul [25]	2019	Brasil	CA+HA+PCO	NP and Berlin questionnaire	AHI ≥ 5 or AHI ≥ 15 with or without sleep complaints	Comparative cross-sectional study

NP, nocturnal polysomnography; AHI, apnea-hypopnea index; RDI, respiratory disturbance index; CA, chronic anovulation; HA, hyperandrogenemia; PCO, polycystic ovary; NS, not specified.

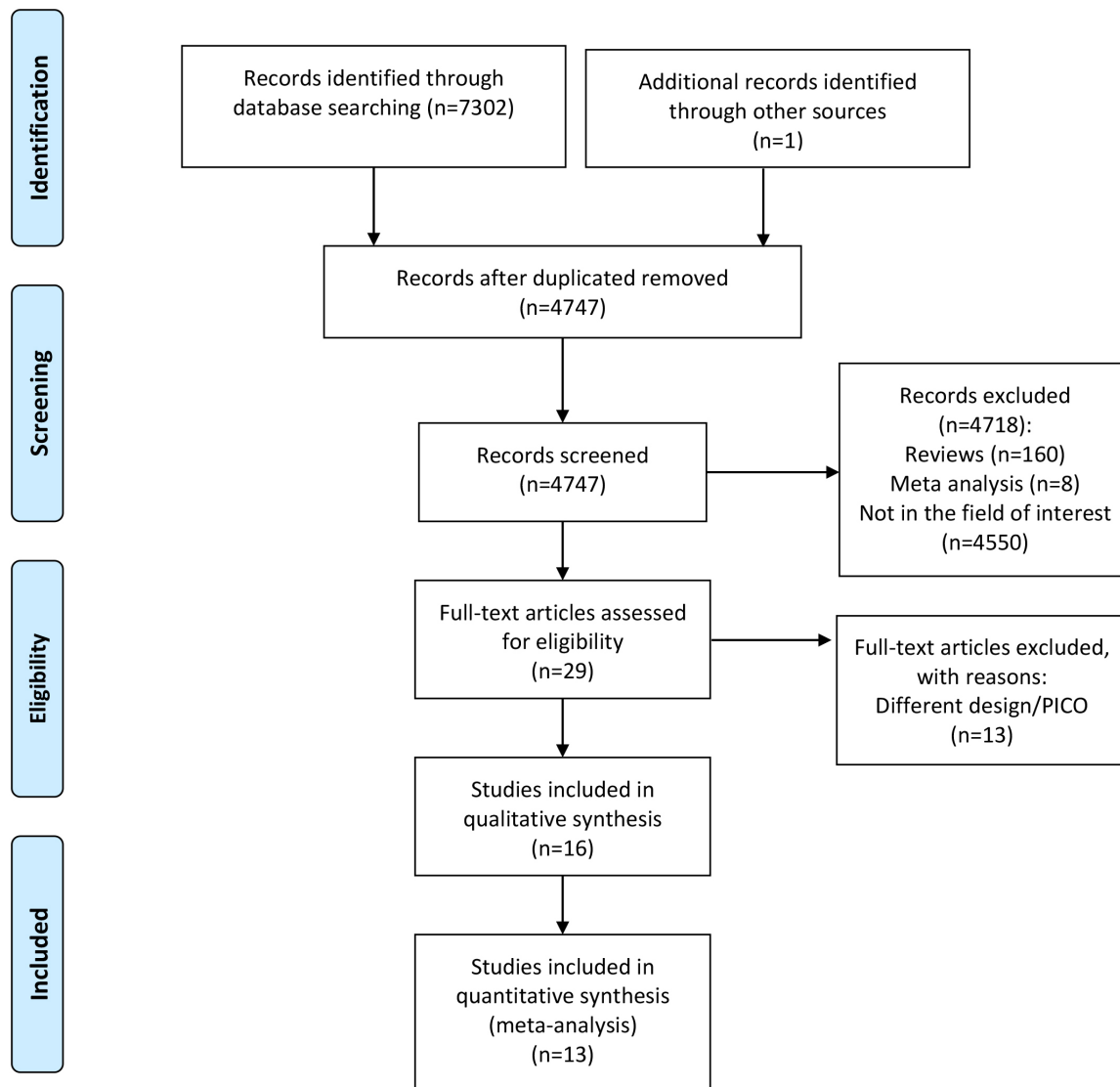


Fig. 1. Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) flowchart. PICO, population, intervention, control, and outcome.

2.3 Statistical Analysis

Statistical analysis was performed using a meta-analytic approach to compare the association between polycystic ovary syndrome (PCOS) and the risk of obstructive sleep apnea (OSA). Pooled risk ratios (RRs) with 95% confidence intervals (CIs) were calculated under both fixed-effect and random-effects models to account for within- and between-study variability. Heterogeneity across studies was assessed using Cochran’s Q test ($p < 0.10$ indicating significant heterogeneity) and quantified by the I^2 statistic and the between-study variance (τ^2), which was estimated using the DerSimonian-Laird method. Individual studies were weighted according to their sample size and variance, with different weighting schemes applied under the two models. All analyses were conducted in R (version 4.1.3, R Foundation for Statistical Computing, Vienna, Austria) using the meta package (version 8.0-2). The I^2

statistic was used to determine the degree of heterogeneity, where the percentages quantified the magnitude of heterogeneity: 25%, low; 50%, medium; and 75%, high heterogeneity. All p -value smaller the 0.05 were considered statistically significant. A funnel plot was added to visually evaluate the publication bias or small study among the studies included.

3. Results

3.1 Eligible Studies

After de-duplication, 4747 of 7303 records underwent title and abstract screening (Fig. 1). After exclusion criteria, 4718 studies were excluded. 13 articles with different research designs were excluded, and 16 articles were finally included for qualitative analysis (Fig. 1) [21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36].

Table 2. Obstructive sleep apnea and AHI, between the PCOS and control group.

First author	Age PCOS/control	BMI PCOS/control	AHI PCOS/control	Number of subjects, PCOS/control	Number of subjects with OSA, PCOS/control
Vgontzas [31]	30.4 ± 0.9/32.1 ± 0.3	38.7 ± 1.1/26.4 ± 0.3	Not specified	53/452	9/3
Fogel [24]	31.1 ± 1.3/32.3 ± 1.3	36.9 ± 1.3/36.9 ± 1.4	22.5 ± 6.0/6.7 ± 1.4	18/18	8/1
Vgontzas [32]	29.6 ± 0.9/35.7 ± 1.0	38.7 ± 1.4/36.9 ± 1.0	1.2 ± 0.6/0.9 ± 0.4	42/17	0/0
Tasali [30]	29.7 ± 0.7/30.7 ± 1.1	39.2 ± 1.0/36.0 ± 1.5	Not specified	52/21	29/4
Gopal [35]	Premenopausal/no control	31.4–67	2.1–126.7	23	16
Chatterjee [34]	Adult/no control	Not specified	Not specified	50	33
Tock [36]	28.3 ± 6.8/no control	32.9 ± 7.7	8.4 ± 16.1	38	12
Yang [33]	29.1 ± 1.4/31.6 ± 3.9	21.7 ± 0.57/20.9 ± 0.58	0.79 ± 0.21/0.29 ± 0.09	18/10	0/0
De Sousa [21]	15.2 ± 1.3/15.0 ± 1.0	31.7 ± 6.2/34.8 ± 8.7	1.03 ± 1.30/1.06 ± 0.79	22/11	0/0
De Sousa [22]	15.7 ± 1.9/15.3 ± 1.0	36.2 ± 6.2/34.4 ± 6.5	0.73 ± 0.82/0.47 ± 0.5	14/19	0/0
De Sousa [23]	17.8 ± 1.1/19.4 ± 0.7	32.7 ± 7.0/21.7 ± 2	0.77 ± 0.88/1.09 ± 1.05	15/16	0/0
Nandalike [28]	16.8 ± 1.9/17.1 ± 1.8	44.8 ± 8.8/40.2 ± 4.7	6.1 ± 6.9/2.2 ± 3.2	28/28	16/4
Suri [29]	27.9 ± 6.44/28.3 ± 6.05	28.0 ± 4.01/25.3 ± 2.93	22.5 ± 21.5/9.0 ± 5.6	50/100	33/44
Lin [27]	28.0 ± 6.79/28.0 ± 6.79	44.8 ± 8.8/40.2 ± 4.7	Not specified	4595/4595	54/20
Kumarendran [26]	30.2 ± 7.4/30.4 ± 7.3	28.6 ± 7.6/27.4 ± 6.4	Not specified	76,978/143,077	298/222
Hachul [25]	29.7 ± 1.2/27.9 ± 1.7	34.3 ± 1.1/22.4 ± 1.6	15/5	30/14	9/0

AHI, apnea-hypopnea index; BMI, body mass index; OSA, obstructive sleep apnea; PCOS, polycystic ovary syndrome.

3.2 Study Characteristics

The studies were published between 2001 and 2019. Study characteristics are summarized in Tables 1,2. A total of 13 studies with 230,293 subjects were included in this meta-analysis, 148,378 patients in the control group [21,22,23,24,25,26,27,28,29,30,31,32,33], and 81,915 in the PCOS group [21,22,23,24,25,26,27,28,29,30,31,32,33]. Six studies were conducted in north America [24,28,30,31,32,35], four studies in Europe [21,22,23,26], four in Asia [27,29,33,34] and two in the south of America [25,36]. We exclusively included articles that adopted nocturnal polysomnography for diagnosing OSA, with different apnea-hypopnea index (AHI) cut-off, ≥ 5 , >5 or ≥ 10 or respiratory disturbance index (RDI) ≥ 5 or >15 . The PCOS was defined with two of the following criteria: Chronic anovulation, hyperandrogenaemia or polycystic ovary (PCO). Only 1 study did not specify the PCOS diagnostic criteria [35]. The mean age of the studies included range from 15 years to 35 years, two studies included patients with grade III obesity [27,28]. AHI was not specified in 4 studies [26,27,31,34].

3.3 Risk of Bias Assessment

Fig. 2 (Ref. [21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36]) displays the quality per study, while Fig. 3 shows a summary of the percentage points expressing the quality of methodology across all studies. The majority of the studies expressed a low risk of bias in reporting, attrition, performance, and detection bias. Selection bias due to inadequate participant selection was high in eight studies and unclear in eight.

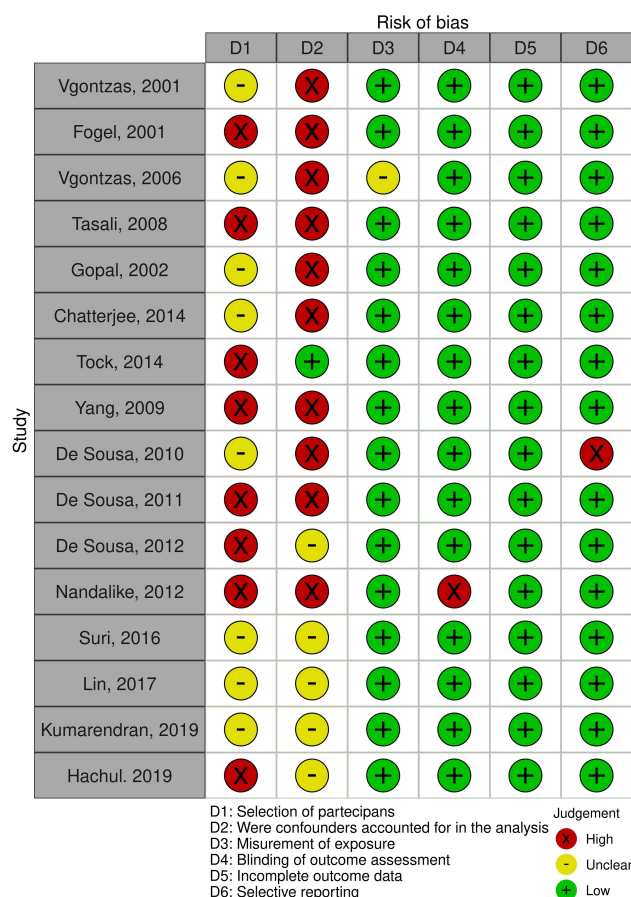


Fig. 2. Risk of Bias Assessment tool for Non-randomized Studies (RoBANS).

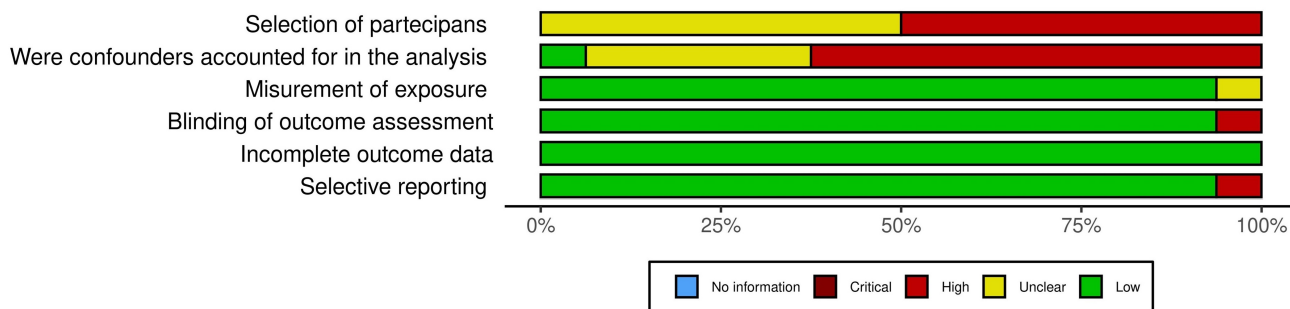


Fig. 3. Overall risk of bias summary. The terms “No information” and “Critical” were automatically generated by the software and do not correspond to categories present in the current dataset. The software uses the updated risk of bias framework, and these terms cannot be removed.

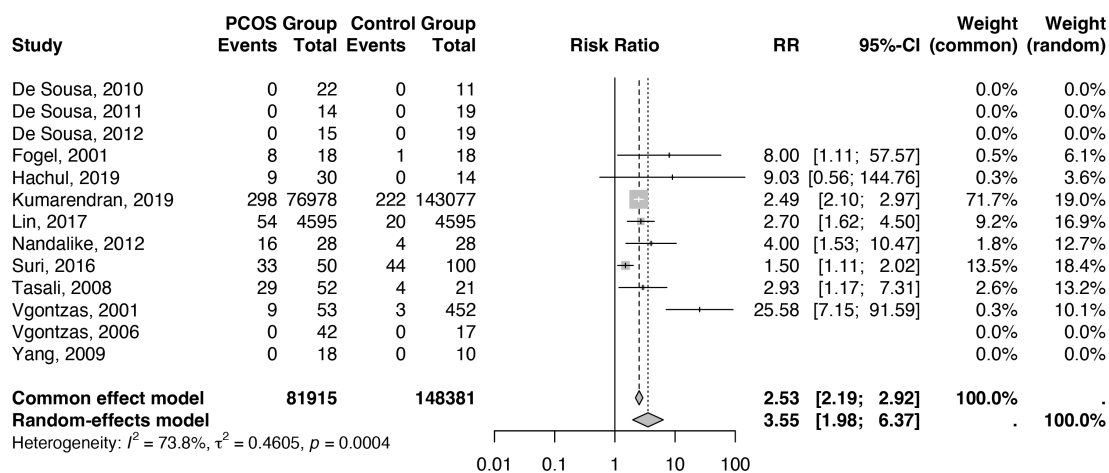


Fig. 4. Forest plot. RR, risk ratio; CI, confidence interval.

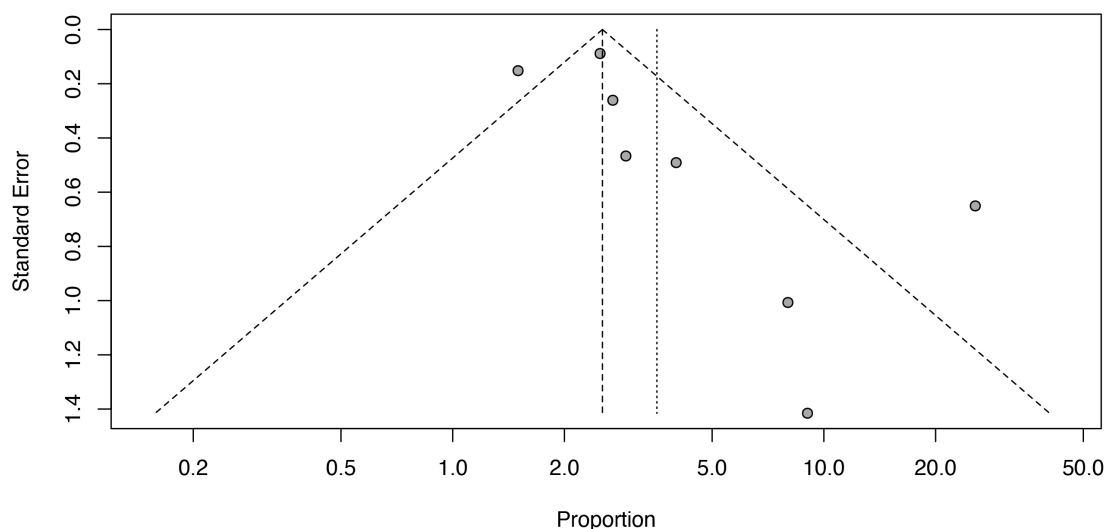


Fig. 5. Funnel plot.

3.4 Primary Outcome Measures

PCOS group have a significant risk of OSA, the pooled analysis showed a risk ratio of 2.53 (95% CI: 2.19–2.92, $p < 0.001$) under the common effect model and 3.55 (95% CI: 1.98–6.37, $p < 0.001$) under the random-effects

model (Fig. 4, Ref. [21,22,23,24,25,26,27,28,29,30,31,32, 33]). High heterogeneity was present ($I^2 = 73.8\%$, $\tau^2 = 0.4605$, $p = 0.0004$). The funnel plot (Fig. 5) showed possible small-study effects.

4. Discussion

4.1 Summary of the Result

We examined the prevalence of OSA in PCOS and we found a high OSA prevalence in PCOS patients. The pooled RR was 3.55 (95% CI 1.98–6.37). A meta-analysis conducted by Helvacı et al. [15] did not observe a risk of OSA in adolescent patients with PCOS, while in adults with PCOS, risk was 9.74 fold higher. Vgontzas et al. [31] and Fogel et al. [24] in 2001 indicated a potential bidirectional relation between PCOS and OSA. Recent large population-based retrospective cohort studies conducted by Kumarendran et al. [26] established that women with PCOS showed an increased risk of OSA, irrespective of obesity. Lin et al. [27] in Taiwan demonstrated an increased risk of developing OSA in later life in PCOS patients. Kahal et al. [37] comprehensively reviewed the clinical interaction and pathophysiology between OSA and PCOS. This review focuses mainly on the potential role that androgens and insulin resistance might play in enhancing the susceptibility to OSA among females with PCOS [38]. The high OSA prevalence in PCOS patients could be attributed to different factors related to PCOS conditions, such as increased levels of leptin due to insulin resistance or an increased incidence of obesity. In addition, hormonal PCOS alterations, particularly hyperandrogenism, may be a potentiating factor for OSA [39]. Conversely, chronic inflammation and oxidative stress may contribute to OSA-related sleep-breathing disturbances.

4.2 Strengths and Limitations

This meta-analysis had several strengths, one of which was the large sample and the systematic literature search. Grey literature was explored to minimize underestimation and avoid missing relevant studies. We included patients from different geographic areas. This reflects OSA prevalence in the different groups and races. Nonetheless, this meta-analysis has limitations. A key limitation is the high heterogeneity among the studies selected as regards criteria used for the diagnosis of PCOS or OSA and the designs of studies, as well as the features of the participants and their ages or BMI. This heterogeneity might affect the generalizable conclusion of this meta-analysis. Another limitation is the high risk of bias. This could induce certain bias to the validity of the results and limit our generalizability. A key limitation was missing AHI data in multiple studies. It represents a critical information for OSA diagnosis and severity. These limitations reduce our generalizability and suggest future accurate research to make robust data on the prevalence and characteristics of OSA in PCOS.

4.3 Implications

Our findings have different implications. PCOS patients should screen for OSA to avoid undiagnosed. Care should be multidisciplinary [40]. Clinicians should recognize that therapy can improve OSA symptoms and mood

[41]. CPAP reduces daytime sleepiness and improves sleep quality and oxygenation [42]. This enhances the quality of sleep [42]. In addition, the cognitive ability and mood of the patients improved [43]. OSA management had short and long-term benefits with reduced incidences of cardiovascular complications [42]. Proper treatment may result in good glucose control and sensitivity of insulin, which is quite important, especially for the PCOS condition [44,45].

5. Conclusion

Women with PCOS showed a higher prevalence of OSA. This evidence supports early screening for sleep disorders especially in the PCOS patients. Further studies are necessary to ascertain this relationship, and to improve the PCOS management.

Key Points

- OSA prevalence increased in the PCOS patients.
- Obesity, insulin resistance, and hyperandrogenism, the three putative pathophysiological mechanisms linking PCOS and OSA.
- Prompt identification and tailored testing for OSA in PCOS is necessary and could improve the women's health.

Availability of Data and Materials

All data generated or analysed during this study are included in this published article and its supplementary tables.

Author Contributions

MLV and GM designed the study and interpreted the data. MMM, MLV and AP drafted the manuscript. MF analysed the data. MLV, MMM and AP searched the articles and collected the data. SP, GMN and HU prepared all the figures and contributed to data interpretation and critical revision of the manuscript. LDC made substantial contributions to the study design and data interpretation. All authors contributed to revising the manuscript critically for important intellectual content. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

The authors thank the AI-RITM interdepartmental project for its support in this research and the Department of Woman, Child and General and Specialized Surgery, University of Campania "Luigi Vanvitelli".

Funding

This research received no external funding.

Conflict of Interest

Giuseppe Minervini was serving as one of the Editorial Board Members of this journal. We declare that Giuseppe Minervini had no involvement in the review of this article and has no access to information regarding its review. The authors declare that they have no competing interests. Full responsibility for the editorial process for this article was delegated to John Alcolado.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.31083/BJHM55373>.

References

- [1] Liu J, Wu Q, Hao Y, Jiao M, Wang X, Jiang S, et al. Measuring the global disease burden of polycystic ovary syndrome in 194 countries: Global Burden of Disease Study 2017. *Human Reproduction*. 2021; 36: 1108–1119. <https://doi.org/10.1093/humrep/deaa371>.
- [2] Deswal R, Narwal V, Dang A, Pundir CS. The Prevalence of Polycystic Ovary Syndrome: A Brief Systematic Review. *Journal of Human Reproductive Sciences*. 2020; 13: 261–271. https://doi.org/10.4103/jhrs.JHRS_95_18.
- [3] Louwers YV, Laven JSE. Characteristics of polycystic ovary syndrome throughout life. *Therapeutic Advances in Reproductive Health*. 2020; 14: 2633494120911038. <https://doi.org/10.1177/2633494120911038>.
- [4] Livadas S, Anagnostis P, Bosdou JK, Bantouna D, Paparodis R. Polycystic ovary syndrome and type 2 diabetes mellitus: A state-of-the-art review. *World Journal of Diabetes*. 2022; 13: 5–26. <https://doi.org/10.4239/wjcd.v13.i1.5>.
- [5] Ezeh U, Ida Chen YD, Azziz R. Racial and ethnic differences in the metabolic response of polycystic ovary syndrome. *Clinical Endocrinology*. 2020; 93: 163–172. <https://doi.org/10.1111/cen.14193>.
- [6] Mumusoglu S, Yildiz BO. Polycystic ovary syndrome phenotypes and prevalence: differential impact of diagnostic criteria and clinical versus unselected population. *Current Opinion in Endocrine and Metabolic Research*. 2020; 12: 66–71. <https://doi.org/10.1016/j.coemr.2020.03.004>.
- [7] Sendur SN, Yildiz BO. Influence of ethnicity on different aspects of polycystic ovary syndrome: a systematic review. *Reproductive Biomedicine Online*. 2021; 42: 799–818. <https://doi.org/10.1016/j.rbmo.2020.12.006>.
- [8] Gilbert EW, Tay CT, Hiam DS, Teede HJ, Moran LJ. Comorbidities and complications of polycystic ovary syndrome: An overview of systematic reviews. *Clinical Endocrinology*. 2018; 89: 683–699. <https://doi.org/10.1111/cen.13828>.
- [9] Vgontzas AN, Bixler EO, Chrousos GP. Metabolic disturbances in obesity versus sleep apnoea: the importance of visceral obesity and insulin resistance. *Journal of Internal Medicine*. 2003; 254: 32–44. <https://doi.org/10.1046/j.1365-2796.2003.01177.x>.
- [10] Wali SO, Abaalkhail B, AlQassas I, Alhejaili F, Spence DW, Pandi-Perumal SR. The correlation between oxygen saturation indices and the standard obstructive sleep apnea severity. *Annals of Thoracic Medicine*. 2020; 15: 70–75. https://doi.org/10.4103/atm.ATM_215_19.
- [11] Mitra AK, Bhuiyan AR, Jones EA. Association and Risk Factors for Obstructive Sleep Apnea and Cardiovascular Diseases: A Systematic Review. *Diseases*. 2021; 9: 88. <https://doi.org/10.3390/diseases9040088>.
- [12] Lee JJ, Sundar KM. Evaluation and Management of Adults with Obstructive Sleep Apnea Syndrome. *Lung*. 2021; 199: 87–101. <https://doi.org/10.1007/s00408-021-00426-w>.
- [13] Fagundes NCF, Minervini G, Furio Alonso B, Nucci L, Grassia V, d'Apuzzo F, et al. Patient-Reported Outcomes While Managing Obstructive Sleep Apnea With Oral Appliances: A Scoping Review. *The Journal of Evidence-Based Dental Practice*. 2023; 23: 101786. <https://doi.org/10.1016/j.jebdp.2022.101786>.
- [14] Langaliya A, Alam MK, Hegde U, Panakaje MS, Cervino G, Minervini G. Occurrence of Temporomandibular Disorders among patients undergoing treatment for Obstructive Sleep Apnoea Syndrome (OSAS) using Mandibular Advancement Device (MAD): A Systematic Review conducted according to PRISMA guidelines and the Cochrane handbook for systematic reviews of interventions. *Journal of Oral Rehabilitation*. 2023; 50: 1554–1563. <https://doi.org/10.1111/joor.13574>.
- [15] Helvacı N, Karabulut E, Demir AU, Yildiz BO. Polycystic ovary syndrome and the risk of obstructive sleep apnea: a meta-analysis and review of the literature. *Endocrine Connections*. 2017; 6: 437–445. <https://doi.org/10.1530/EC-17-0129>.
- [16] Sam S, Tasali E. Role of obstructive sleep apnea in metabolic risk in PCOS. *Current Opinion in Endocrine and Metabolic Research*. 2021; 17: 46–51. <https://doi.org/10.1016/j.coemr.2021.01.002>.
- [17] Moghetti P, Tosi F. Insulin resistance and PCOS: chicken or egg? *Journal of Endocrinological Investigation*. 2021; 44: 233–244. <https://doi.org/10.1007/s40618-020-01351-0>.
- [18] La Verde M, Marrapodi MM, Palma M, Pisani D, Russo D, Ronsivalle V, et al. Effect of the maternal sleep disturbances and obstructive sleep apnea on fetoplacental Doppler: A systematic review. *Journal of Sleep Research*. 2025; 34: e14460. <https://doi.org/10.1111/jsr.14460>.
- [19] La Verde M, Renata E, Marrapodi MM, Della Corte L, Fordellone M, Uzunçibuk H, et al. Diagnostic Accuracy of the Screening Questionnaires for Obstructive Sleep Apnoea in Pregnancy: A Meta-Analysis and Updated Systematic Review. *Journal of Sleep Research*. 2025. <https://doi.org/10.1111/jsr.70197>. (online ahead of print)
- [20] Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JPA, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *Annals of Internal Medicine*. 2009; 151: W65–W94. <https://doi.org/10.7326/0003-4819-151-4-200908180-00136>.
- [21] de Sousa G, Schlüter B, Buschatz D, Menke T, Trowitzsch E, Andler W, et al. A comparison of polysomnographic variables between obese adolescents with polycystic ovarian syndrome and healthy, normal-weight and obese adolescents. *Sleep & Breathing*. 2010; 14: 33–38. <https://doi.org/10.1007/s11325-009-0276-0>.
- [22] de Sousa G, Schlüter B, Menke T, Trowitzsch E, Andler W, Reinehr T. A comparison of polysomnographic variables between adolescents with polycystic ovarian syndrome with and without the metabolic syndrome. *Metabolic Syndrome and Related Disorders*. 2011; 9: 191–196. <https://doi.org/10.1089/met.2010.0081>.
- [23] de Sousa G, Schlüter B, Buschatz D, Menke T, Trowitzsch E, Andler W, et al. The impact of insulin resistance and hyperandrogenemia on polysomnographic variables in obese adolescents with polycystic ovarian syndrome. *Sleep & Breathing*. 2012; 16: 169–175. <https://doi.org/10.1007/s11325-010-0469-6>.
- [24] Fogel RB, Malhotra A, Pillar G, Pittman SD, Dunaif A, White DP. Increased prevalence of obstructive sleep apnea syndrome in obese women with polycystic ovary syndrome. *The Journal of Clinical Endocrinology and Metabolism*. 2001; 86: 1175–1180. <https://doi.org/10.1210/jcem.86.3.7316>.

- [25] Hachul H, Polesel DN, Tock L, Carneiro G, Pereira AZ, Zanella MT, et al. Sleep disorders in polycystic ovary syndrome: influence of obesity and hyperandrogenism. *Revista Da Associação Médica Brasileira* (1992). 2019; 65: 375–383. <https://doi.org/10.1590/1806-9282.65.3.375>.
- [26] Kumarendran B, Sumilo D, O'Reilly MW, Toulis KA, Gokhale KM, Wijeyaratne CN, et al. Increased risk of obstructive sleep apnoea in women with polycystic ovary syndrome: a population-based cohort study. *European Journal of Endocrinology*. 2019; 180: 265–272. <https://doi.org/10.1530/EJ E-18-0693>.
- [27] Lin TY, Lin PY, Su TP, Li CT, Lin WC, Chang WH, et al. Risk of developing obstructive sleep apnea among women with polycystic ovarian syndrome: a nationwide longitudinal follow-up study. *Sleep Medicine*. 2017; 36: 165–169. <https://doi.org/10.1016/j.sleep.2016.12.029>.
- [28] Nandalike K, Agarwal C, Strauss T, Coupey SM, Isasi CR, Sin S, et al. Sleep and cardiometabolic function in obese adolescent girls with polycystic ovary syndrome. *Sleep Medicine*. 2012; 13: 1307–1312. <https://doi.org/10.1016/j.sleep.2012.07.002>.
- [29] Suri J, Suri JC, Chatterjee B, Mittal P, Adhikari T. Obesity may be the common pathway for sleep-disordered breathing in women with polycystic ovary syndrome. *Sleep Medicine*. 2016; 24: 32–39. <https://doi.org/10.1016/j.sleep.2016.02.014>.
- [30] Tasali E, Van Cauter E, Hoffman L, Ehrmann DA. Impact of obstructive sleep apnea on insulin resistance and glucose tolerance in women with polycystic ovary syndrome. *The Journal of Clinical Endocrinology and Metabolism*. 2008; 93: 3878–3884. <https://doi.org/10.1210/jc.2008-0925>.
- [31] Vgontzas AN, Legro RS, Bixler EO, Grayev A, Kales A, Chrousos GP. Polycystic ovary syndrome is associated with obstructive sleep apnea and daytime sleepiness: role of insulin resistance. *The Journal of Clinical Endocrinology and Metabolism*. 2001; 86: 517–520. <https://doi.org/10.1210/jcem.86.2.7185>.
- [32] Vgontzas AN, Trakada G, Bixler EO, Lin HM, Pejovic S, Zoumakis E, et al. Plasma interleukin 6 levels are elevated in polycystic ovary syndrome independently of obesity or sleep apnea. *Metabolism: Clinical and Experimental*. 2006; 55: 1076–1082. <https://doi.org/10.1016/j.metabol.2006.04.002>.
- [33] Yang HP, Kang JH, Su HY, Tzeng CR, Liu WM, Huang SY. Apnea-hypopnea index in nonobese women with polycystic ovary syndrome. *International Journal of Gynaecology and Obstetrics*. 2009; 105: 226–229. <https://doi.org/10.1016/j.ijgo.2009.02.004>.
- [34] Chatterjee B, Suri J, Suri JC, Mittal P, Adhikari T. Impact of sleep-disordered breathing on metabolic dysfunctions in patients with polycystic ovary syndrome. *Sleep Medicine*. 2014; 15: 1547–1553. <https://doi.org/10.1016/j.sleep.2014.06.023>.
- [35] Gopal M, Duntley S, Uhles M, Attarian H. The role of obesity in the increased prevalence of obstructive sleep apnea syndrome in patients with polycystic ovarian syndrome. *Sleep Medicine*. 2002; 3: 401–404. [https://doi.org/10.1016/s1389-9457\(02\)00033-3](https://doi.org/10.1016/s1389-9457(02)00033-3).
- [36] Tock L, Carneiro G, Togeiro SM, Hachul H, Pereira AZ, Tufik S, et al. Obstructive sleep apnea predisposes to nonalcoholic Fatty liver disease in patients with polycystic ovary syndrome. *Endocrine Practice*. 2014; 20: 244–251. <https://doi.org/10.4158/EP12366.OR>.
- [37] Kahal H, Kyrou I, Tahrani AA, Randevara HS. Obstructive sleep apnoea and polycystic ovary syndrome: A comprehensive review of clinical interactions and underlying pathophysiology. *Clinical Endocrinology*. 2017; 87: 313–319. <https://doi.org/10.1111/cen.13392>.
- [38] Kahal H, Kyrou I, Uthman O, Brown A, Johnson S, Wall P, et al. The association between obstructive sleep apnea and metabolic abnormalities in women with polycystic ovary syndrome: a systematic review and meta-analysis. *Sleep*. 2018; 41: 10.1093/sleep/zsy085. <https://doi.org/10.1093/sleep/zsy085>.
- [39] Yang J, Chen C. Hormonal changes in PCOS. *The Journal of Endocrinology*. 2024; 261: e230342. <https://doi.org/10.1530/JOE-23-0342>.
- [40] Arachchige MA, Steier J. Beyond Usual Care: A Multidisciplinary Approach Towards the Treatment of Obstructive Sleep Apnoea. *Frontiers in Cardiovascular Medicine*. 2022; 8: 747495. <https://doi.org/10.3389/fcvm.2021.747495>.
- [41] AlRumaih HS, Baba NZ, AlShehri A, AlHelal A, Al-Humaidan A. Obstructive Sleep Apnea Management: An Overview of the Literature. *Journal of Prosthodontics*. 2018; 27: 260–265. <https://doi.org/10.1111/jopr.12530>.
- [42] Ramar K, Dort LC, Katz SG, Lettieri CJ, Harrod CG, Thomas SM, et al. Clinical Practice Guideline for the Treatment of Obstructive Sleep Apnea and Snoring with Oral Appliance Therapy: An Update for 2015. *Journal of Clinical Sleep Medicine*. 2015; 11: 773–827. <https://doi.org/10.5664/jcsm.4858>.
- [43] Sánchez AI, Martínez P, Miró E, Bardwell WA, Buéla-Casal G. CPAP and behavioral therapies in patients with obstructive sleep apnea: effects on daytime sleepiness, mood, and cognitive function. *Sleep Medicine Reviews*. 2009; 13: 223–233. <https://doi.org/10.1016/j.smrv.2008.07.002>.
- [44] Gaines J, Vgontzas AN, Fernandez-Mendoza J, Bixler EO. Obstructive sleep apnea and the metabolic syndrome: The road to clinically-meaningful phenotyping, improved prognosis, and personalized treatment. *Sleep Medicine Reviews*. 2018; 42: 211–219. <https://doi.org/10.1016/j.smrv.2018.08.009>.
- [45] Bulcun E, Ekici M, Ekici A. Disorders of glucose metabolism and insulin resistance in patients with obstructive sleep apnoea syndrome. *International Journal of Clinical Practice*. 2012; 66: 91–97. <https://doi.org/10.1111/j.1742-1241.2011.02795.x>.