Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Sleep in progressive supranuclear palsy: A systematic review and meta-analysis of polysomnographic findings

Jiaxue Huang
Sichuan University
Meiou Wang
Sichuan University
Wenxin Bao
Sichuan University
Wenqi Lyu
Sichuan University
Yongming Wang
Sichuan University
Shuyao Wu
Sichuan University
Shuancheng Ren
Army Medical University
Xiangdong Tang
Sichuan University
Rong Ren
Sichuan University
Ye Zhang
569389672@qq.com
Sichuan University

Research Article

Keywords: Progressive supranuclear palsy, Sleep, Polysomnography, Neurodegenerative disease

Posted Date: October 27th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10499352/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License

Additional Declarations: No competing interests reported.

Abstract

Purpose

To evaluate polysomnographic measured sleep changes in patients with progressive supranuclear palsy (PSP) compared with controls.

Methods

MEDLINE, EMBASE, All EBM databases, and Web of Science were searched. Eight studies were included in the quantitative meta-analysis, involving 183 individuals with PSP and 158 controls.

Results

Meta-analyses revealed reduced sleep efficiency, total sleep time, and rapid eye movement (REM) sleep percentage, and increased wake time after sleep onset, N1 sleep percentage, REM latency, and apnea hypopnea index in PSP patients compared with controls. No significant group differences were observed in sleep latency, N2 sleep percentage, N3 sleep percentage, or arousal index.

Conclusions

Our meta-analysis found that multiple objective sleep abnormalities are present in individuals with PSP compared with controls. This suggests the potential value of polysomnography in characterizing sleep disturbances in PSP. These findings might be useful for distinguishing PSP from other neurodegenerative diseases. Future research should explore the effects of clinical characteristics (i.e., disease duration, disease severity, and comorbid sleep disorders) on sleep in PSP.

Introduction

Progressive supranuclear palsy (PSP) is a rare, progressive neurodegenerative disease with an age-adjusted prevalence of 2.95 per 100,000 individuals [1]. The average survival for PSP is approximately 6 to 8 years [2, 3]. It is characterized by motor dysfunction such as ocular motor dysfunction, akinesia, and parkinsonism [1, 4]. With the exception of frequently reported motor abnormalities, non-motor symptoms such as cognitive and behavioral issues, systemic and bulbar symptoms, as well as sleep disturbances, should also be given consideration [5].

Among these non-motor symptoms, sleep disturbances are commonly seen, such as insomnia (i.e., sleep fragmentation and early awakening) and rapid eye movement (REM) sleep behavior disorder (RBD) [5, 6]. The prevalence of sleep fragmentation and early awakening is approximately 86% and 53%, respectively, whereas RBD affects 18.5%-28% of patients with PSP [7–10]. Aldrich et al. proposed that insomnia is associated with the severity of disease [11]. RBD is associated with increased severity of both motor and non-motor symptoms, including fatigue, cognitive impairment, and constipation [7]. In addition, sleep disturbances are significantly associated with a fourfold increased risk of mortality [5]. These findings highlight the clinical importance of evaluating sleep characteristics in patients with PSP.

Polysomnography (PSG) represents the gold standard for objective evaluation of sleep. Although previous studies have investigated PSG measured sleep in PSP, the specific changes in sleep parameters (i.e., sleep latency (SL), total sleep time (TST), and the percentage of REM sleep) in PSP relative to controls remain unclear, potentially due to differences in demographic and clinical characteristics. Therefore, we conducted this first meta-analysis and systematic review to identify PSG abnormalities and potential moderators in PSP patients compared to controls where possible.

Methods

Protocol and registration

The study protocol was registered on PROSPERO (ID: CRD420261328606) and conducted in accordance with the PRISMA guidelines for systematic reviews and meta-analyses [12].

Literature searching

We searched MEDLINE, EMBASE, all EBM databases via OVID, and Web of Science using the following search strategy: ("progressive supranuclear palsy or PSP") AND ("Polysomnogra*" OR "PSG" OR "Sleep architect*" OR "Sleep monit*" OR "Sleep stage*"). The initial search was performed on February 24, 2026, with an updated search conducted on April 1, 2026 (Tables S1-S4). Two reviewers conducted independent study selection. Any disagreements were resolved through consultation with the senior author (Y.Z.).

Inclusion and exclusion criteria

Studies were eligible for inclusion if they met the following criteria: (1) PSP should be diagnosed based on the Litvan criteria [13] or the movement disorder society PSP criteria [14]; (2) including healthy controls without PSP; (3) comparing PSG variables between PSP and controls; and (4) written in English. When participants appeared in multiple publications, only the dataset with the most comprehensive information was selected. We excluded guidelines, review papers, editorials, case series/case reports, statements, comments, and animal studies, studies unrelated to PSP, and those reported absence of PSG data or lack of PSG comparisons between PSP patients and controls.

Data collection process and quality assessment of included studies

We extracted TST, wake time after sleep onset (WASO), sleep efficiency (SE), SL, REM latency (REML), arousal index (AI), apnea hypopnea index (AHI), and the percentage of stages N1, N2, N3, and REM sleep. The extracted demographic and clinical data included number of participants, their sex (percentage of male participants), age, body mass index (kg/m^2), adaptation nights (Yes vs. No), disease duration, comorbidities of other sleep disorders (i.e., RBD and restless legs syndrome (RLS)) (Yes vs. No), scores of Mini-Mental State Examination, Epworth Sleepiness Scale, progressive supranuclear palsy rating scale, and Unified Parkinson's Disease Rating Scale part III. Risk of bias in included studies was assessed using the Quality Appraisal Criteria adapted from the Joanna Briggs Institute [15, 16].

Statistical analysis

Meta-analyses were performed with Comprehensive Meta-Analysis software. To determine the combined effect size (standardized mean difference (SMD)) for PSG differences between PSP patients and controls, the sample size, mean, and standard deviation for each group were inputted for computation. To quantify the degree of variation between trials and examine overlap within 95% confidence intervals, heterogeneity was evaluated using the Q statistic and I^2 statistic [17]. Egger's regression test [18] was used to analyze publication bias, with a p value less than 0.05 indicating significant bias. When necessary, sensitivity analysis was conducted where needed to investigate potential sources of heterogeneity.

Results

Study selection

Our search yielded 339 publications (Fig. 1). After removing 90 duplicates, a further 227 records were excluded by screening titles and abstracts. A total of 22 relevant studies were selected for full-text review. Of these, eight studies [6, 7, 19–24] were included in our meta-analysis (Table 1). The excluded studies with reasons for their exclusion are provided in Table S5.

Table 1. Study characteristics

Study	Sample size	Percentage male	Mean age	BMI	MMSE	Daytime sleepiness	PSPRS / UPDRS	Adaptation
Baschieri et al., 2026	14 PSP	42.9%	76 ± 3	26.69 ± 4.5	25.0 ± 2.7	ESS: 6.2 ± 3.6	PSPRS: 51.3 ± 10.7	YES
	12 controls	66.7%	43 ± 12	28.5 ± 4.0	NR	NR	NA	
Arnulf et al., 2005	15 PSP	46.7%	68 ± 8	24.5 ± 4.1	24 ± 5	ESS: 6.7 ± 5.0	UPDRS: 29 ± 14	NO
	15 controls	46.7%	67 ± 10	26.1 ± 5.4	29 ± 1	ESS: 6.9 ± 4.2	NA	
Boini et al., 2022	21 PSP	NR	61.2 ± 7.1	NR	NR	ESS: 4.5 ± 4.1	PSPRS: 30.0 ± 10.7; UPDRS: 29.4 ± 11.1	NO
	15 controls	NR	53.9 ± 4.2	NR	NR	NR	NA	
De Cock et al., 2007	9 PSP	66.7%	66.1 ± 8.8	23.7 ± 3.0	21.6 ± 6.2	ESS: 5.5 ± 3.4	UPDRS: 38 ± 19	NO
	9 controls	66.7%	66.9 ± 9.5	26.8 ± 6.0	NR	ESS: 6.7 ± 5.6	NA	
Levendowski et al., 2022	13 PSP	46.2%	70 ± 9.0	NR	NR	NR	NR	NA
	61 controls	50.8%	65 ± 8.3	NR	NR	NR	NA	
Lu et al., 2025	86 PSP	55.8%	67.9 ± 7.7	NR	NR	ESS: 4.9 ± 4.7	NR	NO
	24 controls	50.0%	64.6 ± 5.3	NR	NR	ESS: 6.4 ± 3.9	NA	
Walsh et al., 2017	19 PSP	68%	70.94 ± 4.36	NR	23.06 ± 0.9	MSLT: 17.63 ± 2.1	PSPRS: 39.9 ± 17.44	NO
	16 controls	44%	72.50 ± 4	NR	29.27 ± 0.3	MSLT: 11.66 ± 4.8	NA	
Montplaisir et al., 1997	6 PSP	83%	70.5 ± 6.0	NR	NR	NR	NR	NO
	6 controls	83%	69.8 ± 4.4	NR	NR	NR	NA	

PSP, progressive supranuclear palsy; NR, not reported; BMI, body mass index; MMSE, Mini-Mental State Examination; ESS, Epworth sleepiness scale; MSLT, multiple sleep latency test; PSPRS, the progressive supranuclear palsy rating scale; UPDRS, Unified Parkinson's Disease Rating Scale; NA, not applicable.

Description of the included studies

As shown in Table 1, there were a total of 183 patients with PSP and 158 controls in the eight included studies. For patients with PSP, mean age ranged from 61.2–76 years and the percentage of males ranged from 42.9 to 83%. For controls, mean age ranged from 43-72.5 years and the percentage of males ranged from 44 to 83%. For adaptation night, only one study [24] incorporated an adaptation night for PSG recordings, whereas six studies [6, 7, 19–22] conducted only one night of PSG without an adaptation period, and one study [23] conducted PSG recordings at home. The quality assessments of included studies are provided in Table S6.

Meta-analyses

Meta-analysis revealed significantly decreased TST, SE, percentage of REM sleep, and increased WASO, percent N1, REML, and AHI in patients with PSP compared with controls (Fig. 2 and Table 2). No significant differences were observed for SL, percent N2, N3, and AI. Egger's test revealed publication bias for increased percent N1, percent REM, and REML ($p < 0.05$), whereas no publication bias was detected for other significant findings ($p > 0.05$) (Figure S1-S11).

Table 2
Summary of meta-analysis comparing PSP individuals and controls

TST, min	**No. of comparisons**	**No. of PSP/controls**	**Means of PSP**	**Means of controls**	**SMD (95%CI)**	***Q***	I^2
	8	**183/158**	**323.88**	**401.80**	**-0.826 (-1.137 to -0.516)*** **	**10.161**	**31.110**
WASO, min	5	91/128	194.65	72.01	1.610 (0.829 to 2.391)***	28.082	82.195
Sleep efficiency, %	8	183/158	64.74	82.32	-1.536 (-2.117 to -0.955)***	30.740	77.229
Sleep latency, min	7	177/152	27.47	17.67	0.394 (-0.043 to 0.831)	17.443	65.603
N1%	8	183/158	22.39	8.79	1.092 (0.721 to 1.463)***	13.342	47.536
N2%	8	183/158	46.89	50.25	-0.427 (-1.090 to 0.236)	46.035	84.794
N3%	8	183/158	8.05	19.44	-1.477 (-3.010 to 0.055)	197.032	96.447
REM %	8	183/158	13.30	20.56	-1.679 (-2.472 to -0.886)***	54.636	87.188
REM latency, min	7	170/97	141.99	92.11	0.774 (0.293 to 1.255)**	16.952	64.607
Arousal index (events/hour)	3	37/85	38.21	20.02	0.446 (-0.089 to 0.982)	3.085	35.165
Apnea-Hypopnea index (events/hour)	3	110/48	18.68	8.35	0.804 (0.158 to 1.451)*	4.913	59.289

PSP, progressive supranuclear palsy; TST, total sleep time; WASO, wake after sleep onset; %, percentage; REM, rapid eye movement; SMD, standardized mean difference; *Q*, Cochran's Q statistic.

*$p < .05$, **$p < .01$, ***$p < .001$.

Source of heterogeneity across studies

Among the eight studies reviewed, one study exhibited a significant age disparity between patients with PSP and controls. Sensitivity analysis excluding this study revealed that the directions of PSG changes (decreased or increased) remained consistent in the whole sample analysis.

Discussion

Summary of findings

To our knowledge, this is the first meta-analysis to examine PSG changes in PSP patients compared with controls. Our results indicated that PSP patients showed significantly decreased TST, SE, and REM sleep percentage, and increased WASO, percent N1, REML, and AHI compared with controls, while no significant differences were found for percent N2, N3, AI and SL.

Sleep abnormalities in PSP

Subjectively, sleep disturbances are commonly reported in PSP. For instance, the prevalence rates of sleep fragmentation and early awakening were 86% and 53%, respectively [10]. Objectively, an actigraphy study showed significantly decreased TST and increased nocturnal sleep fragmentation in PSP patients compared with controls [25]. However, self-reported and actigraphic sleep parameters may be insufficient for comprehensively characterizing sleep quality and quantity, as well as for elucidating the pathophysiological mechanisms underlying PSP. Our meta-analysis revealed significant PSG alterations, such as significantly decreased TST, SE, and REM sleep percentage in PSP patients compared with controls. Boini et al. discovered a negative correlation between TST and disease severity in PSP [22]. Furthermore, Ibrahim et al. reported that decreases in SE and REM sleep were associated with an increased risk of neurodegenerative disease [26]. However, the mechanisms underlying sleep alterations in PSP remain unclear. It is known that gray matter atrophy in the midbrain and white matter atrophy in the midbrain, cerebral, and superior/middle cerebellar pedunculi are characteristic hallmarks of PSP [27], which are crucial for the regulation of sleep and wakefulness [28, 29].

Sleep disturbances are common in neurodegenerative diseases, such as multiple system atrophy (MSA), Alzheimer's disease (AD), amyotrophic lateral sclerosis (ALS), and Parkinson's disease (PD) [30–33]. PD, AD, and ALS all exhibit significantly decreased TST, SE, and increased WASO and percent N1 compared with controls [30–32], which are also observed in patients with PSP in our meta-analysis. By comparison, PSP is characterized by a significantly increased AHI, whereas this parameter remains unchanged in AD [31]. Furthermore, PSP exhibited significantly increased REML, a finding not observed in patients with MSA [33]. In addition, significantly decreased percentage of REM sleep is observed in PSP but not in patients with ALS [30]. These findings underscore the distinct PSG characteristics across different neurodegenerative diseases [34, 35].

Our findings revealed an elevated AHI in PSP patients compared with controls. A postmortem study reported tau pathology in the ventral respiratory group (VRG) in PSP patients. The VRG is a critical component of medullary respiratory centers, and its impairment may result in central hypoventilation syndrome [36]. Furthermore, a meta-analysis reported that dysphagia is highly prevalent in PSP, with a prevalence of 78%-89% [37]. Neuroimaging studies revealed that pharyngeal phase dysphagia was associated with disruption to the cerebral peduncle, medial frontal lobe, and corticospinal tract [38], which may impair coordination between upper airway and diaphragmatic musculature, increasing the risk of obstructive sleep apnea [39]. These may partly explain the increased AHI in PSP.

Considerations of comorbidities of sleep disorders

RBD and RLS are also common in PSP, with a reported prevalence of up to 28% and 58%, respectively [7, 40]. Previous studies have shown that patients with idiopathic RBD exhibit increased SL and N3 sleep percentage, and decreased TST and SE compared with healthy controls [41]. Idiopathic RLS patients also showed significant reductions in TST, SE, stage

N2 percentage and REM sleep percentage, and increases in WASO, stage N1 percentage, REM latency, and AHI [42]. Therefore, it is possible that comorbid RBD and/or RLS contribute to the PSG alterations observed in PSP patients in our meta-analysis findings. Among the included studies, the majority of studies did not exclude or report patients with comorbid RBD or RLS. However, due to the limited number of studies, we do not have sufficient data to perform a meta-regression analysis to explore the impacts of RBD and RLS on PSG changes in PSP, which is an important direction for future studies.

Effects of drugs

The use of drugs impacting sleep might be a factor which results in sleep changes of patients with PSP. Given that patients with PSP commonly show severe sleep problems and/or movement disorders [1, 4], withdrawal of pharmacotherapy is unethical and would have a negative impact on patients with PSP. In our meta-analysis, seven of the included studies did not exclude patients using medication that impacts sleep (i.e., benzodiazepines and dopaminergic medications). One study did not report whether patients took medication impacting sleep. A systematic review found that benzodiazepines increase N2 sleep while decreasing N3 and REM sleep [43]. Moreover, dopaminergic medications are associated with increased percent N2 and decreased REM sleep [44]. Thus, our findings may be impacted by possible pharmacotherapy.

Limitations

First, the relatively small number of included studies may have limited statistical power. Second, the potential differences between different clinically phenotype remain unclear. Whether the findings of our meta-analysis are applicable to distinct PSP phenotype (such as Richardson's syndrome, Parkinsonian variant, and Predominance of ocular motor symptoms) is unclear. Third, in our meta-analysis, patients taking medications that impact sleep were not excluded, nor was their medication use reported, which may bias our findings. Fourth, exploring the contributions of RLS and RBD to PSG changes in PSP is warranted. Fifth, due to limited data, we could not explore whether differences in clinical characteristics (i.e., disease duration and disease severity) impact our meta-analysis findings. These findings suggest that our findings should be interpreted cautiously.

Conclusion

Our meta-analysis demonstrated significant PSG abnormalities in PSP patients compared with controls. Despite the methodological heterogeneity across the included studies, our findings indicate that objective sleep disturbances represent a prominent clinical feature of PSP. PSG may help elucidate the pathophysiology and etiology of PSP. Our findings also highlight the importance of accounting for the effects of potential factors (i.e., disease duration, comorbidity with RBD or RLS) on PSG changes in PSP.

Declarations

Acknowledgements

JXH, YZ designed the study. JXH drafted the manuscript. JXH, MOW contributed to database preparation. JXH and MOW contributed to accuracy checks. XDT, YZ, RR, WXB, WQL, YMW, and SYW provided important suggestions for improving the manuscript and critically revised the manuscript. All authors commented on and approved drafts and the final manuscript.

Author Contributions

Jiaxue Huang: Conceptualization, Writing - original draft, Methodology, Investigation, Formal analysis, Data curation. **Meiou Wang:** Writing - review & editing, Data curation, Validation, Supervision. **Wenxin Bao:** Writing - review & editing, Validation, Supervision. **Wenqi Lyu:** Writing - review & editing, Validation, Supervision. **Yongming Wang:** Writing - review & editing, Validation, Supervision. **Shuyao Wu:** Writing - review & editing, Validation, Supervision. **Xiangdong Tang:** Writing - review &

editing, Validation, Supervision, Funding acquisition. **Rong Ren:** Writing - review & editing, Validation, Supervision, Funding acquisition. **Ye Zhang:** Conceptualization, Writing - review & editing, Validation, Supervision, Funding acquisition.

Funding

This study is supported by the Ministry of Science and Technology of the People's Republic of China (2025ZD0216400) and the National Natural Science Foundation of China (82341249, 82470095, 82120108002).

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Competing interests

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript. Additionally, Ye Zhang - although the co-author is the Editor of the journal, there was no involvement with the peer review process for this article.

Ethics approval

This article is a systematic review and meta-analysis of previously published aggregate data. The manuscript does not contain clinical studies or patient data.

Consent to participate Not applicable.

Consent to publish Not applicable.

References

1. Viscidi E, Litvan I, Dam T*, et al*. Clinical Features of Patients With Progressive Supranuclear Palsy in an US Insurance Claims Database. Article. *Frontiers in Neurology*. 2021;12571800. doi:10.3389/fneur.2021.571800
2. Höglinger GU, Litvan I, Mendonca N*, et al*. Safety and efficacy of tilavonemab in progressive supranuclear palsy: a phase 2, randomised, placebo-controlled trial. *Lancet Neurol*. Mar 2021;20(3):182-192. doi:10.1016/s1474-4422(20)30489-0
3. McFarland NR. Diagnostic Approach to Atypical Parkinsonian Syndromes. Review. *CONTINUUM Lifelong Learning in Neurology*. 2016;22(4,MovementDisorders):1117-1142. doi:10.1212/CON.0000000000000348
4. Arena JE, Weigand SD, Whitwell JL*, et al*. Progressive supranuclear palsy: progression and survival. *J Neurol*. Feb 2016;263(2):380-389. doi:10.1007/s00415-015-7990-2
5. Arnulf I, Merino-Andreu M, Bloch F*, et al*. REM sleep behavior disorder and REM sleep without atonia in patients with progressive supranuclear palsy. *Sleep*. 2005;28(3):349-54.
6. Lu HT, Ren JF, Liu H*, et al*. Prevalence and correlated factors of REM sleep behavior disorder in patients with progressive supranuclear palsy. *SLEEP MEDICINE*. NOV 2025;135106767. doi:10.1016/j.sleep.2025.106767
7. Lim S-Y, Dy Closas AMF, Tan AH*, et al*. New insights from a multi-ethnic Asian progressive supranuclear palsy cohort. *Parkinsonism & Related Disorders*. 2023/03/01/ 2023;108:105296. doi:https://doi.org/10.1016/j.parkreldis.2023.105296

8. Muinjonov B, Giyaziddinova E. Sleep disorders in progressive supranuclear palsy. *MOVEMENT DISORDERS*. JUN 2016;31:S66-S66.
9. Aldrich MS, Foster NL, White RF, Bluemlein L, Prokopowicz G. Sleep abnormalities in progressive supranuclear palsy. *Annals of neurology*. Jun 1989;25(6):577-81. doi:10.1002/ana.410250609
10. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*. 2010/01/01/ 2010;8(5):336-341. doi:https://doi.org/10.1016/j.ijsu.2010.02.007
11. Litvan I, Agid Y, Calne D*, et al*. Clinical research criteria for the diagnosis of progressive supranuclear palsy (Steele-Richardson-Olszewski syndrome): report of the NINDS-SPSP international workshop. *Neurology*. Jul 1996;47(1):1-9. doi:10.1212/wnl.47.1.1
12. Höglinger GU, Respondek G, Stamelou M*, et al*. Clinical diagnosis of progressive supranuclear palsy: The movement disorder society criteria. *Movement disorders : official journal of the Movement Disorder Society*. Jun 2017;32(6):853-864. doi:10.1002/mds.26987
13. Moola S, Tufanaru C, Aromataris E*, et al*. Chapter 7: Systematic Reviews of Etiology and Risk. 2020.
14. Halstead S, Siskind D, Amft M*, et al*. Alteration patterns of peripheral concentrations of cytokines and associated inflammatory proteins in acute and chronic stages of schizophrenia: a systematic review and network meta-analysis. *The lancet Psychiatry*. Apr 2023;10(4):260-271. doi:10.1016/s2215-0366(23)00025-1
15. Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. *BMJ (Clinical research ed)*. Sep 6 2003;327(7414):557-60. doi:10.1136/bmj.327.7414.557
16. Egger M, Davey Smith G, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. *BMJ (Clinical research ed)*. Sep 13 1997;315(7109):629-34. doi:10.1136/bmj.315.7109.629
17. Montplaisir J, Petit D, Décary A*, et al*. Sleep and quantitative EEG in patients with progressive supranuclear palsy. *Neurology*. Oct 1997;49(4):999-1003. doi:10.1212/wnl.49.4.999
18. De Cock VC, Lannuzel A, Verhaeghe S*, et al*. REM sleep behavior disorder in patients with Guadeloupean parkinsonism, a tauopathy. *Sleep*. 2007;30(8):1026-1032. doi:https://dx.doi.org/10.1093/sleep/30.8.1026
19. Walsh CM, Ruoff L, Walker K*, et al*. Sleepless Night and Day, the Plight of Progressive Supranuclear Palsy. *Sleep*. 2017;40(11)doi:https://dx.doi.org/10.1093/sleep/zsx154
20. Boini S, Mahale R, Donaparthi S*, et al*. Sleep Architecture in Progressive Supranuclear Palsy: A Video-Polysomnography Study. *ANNALS OF INDIAN ACADEMY OF NEUROLOGY*. SEP-OCT 2022;25(5):858-863. doi:10.4103/aian.aian_1096_21
21. Levendowski DJ, Walsh CM, Boeve BF*, et al*. Non-REM sleep with hypertonia in Parkinsonian Spectrum Disorders: A pilot investigation. *Sleep Medicine*. 2022;100:501-510. doi:https://dx.doi.org/10.1016/j.sleep.2022.09.025
22. Baschieri F, Sambati L, Antenucci P*, et al*. Circadian Rhythms of Sleep-Wake, Thermoregulatory and Cardiovascular Function in Progressive Supranuclear Palsy. *Movement disorders clinical practice*. 2026;13(2):410-418. doi:https://dx.doi.org/10.1002/mdc3.70346
23. Walsh CM, Ruoff L, Varbel J*, et al*. Rest-activity rhythm disruption in progressive supranuclear palsy. *Sleep Med*. Jun 2016;22:50-56. doi:10.1016/j.sleep.2016.05.002
24. Ibrahim A, Cesari M, Heidbreder A*, et al*. Sleep features and long-term incident neurodegeneration: a polysomnographic study. *Sleep*. Mar 11 2024;47(3)doi:10.1093/sleep/zsad304
25. Albrecht F, Bisenius S, Neumann J, Whitwell J, Schroeter ML. Atrophy in midbrain & cerebral/cerebellar pedunculi is characteristic for progressive supranuclear palsy - A double-validation whole-brain meta-analysis. *NeuroImage Clinical*. 2019;22:101722. doi:10.1016/j.nicl.2019.101722
26. Canto CB, Onuki Y, Bruinsma B, van der Werf YD, De Zeeuw CI. The Sleeping Cerebellum. *Trends in Neurosciences*. 2017/05/01/ 2017;40(5):309-323. doi:https://doi.org/10.1016/j.tins.2017.03.001

27. Zhang Y, Ren R, Yang L*, et al*. Sleep in amyotrophic lateral sclerosis: A systematic review and meta-analysis of polysomnographic findings. *Sleep Medicine*. 2023/07/01/ 2023;107:116-125. doi:https://doi.org/10.1016/j.sleep.2023.04.014
28. Zhang Y, Ren R, Yang L*, et al*. Sleep in Alzheimer's disease: a systematic review and meta-analysis of polysomnographic findings. *Translational psychiatry*. Apr 1 2022;12(1):136. doi:10.1038/s41398-022-01897-y
29. Zhang Y, Ren R, Sanford LD*, et al*. Sleep in Parkinson's disease: A systematic review and meta-analysis of polysomnographic findings. *Sleep Med Rev*. Jun 2020;51:101281. doi:10.1016/j.smrv.2020.101281
30. Wang M, Zhang Y, Ren R*, et al*. Polysomnographic findings of multiple system atrophy: evidence from case-control studies. *Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine*. Oct 1 2025;21(10):1723-1732. doi:10.5664/jcsm.11758
31. Antonioni A, Della Valle A, Leitner C*, et al*. Sleep Disturbances Across Dementias and Cognitive Decline: Study Protocol for a Systematic Review and Network Meta-Analysis of Polysomnographic Findings. 2025;14
32. Herrick KS, Woltjer R, Pham T, Chalupsky M, Hiller AL. Central hypoventilation in progressive supranuclear palsy. *Mov Disord Clin Pract*. Jan-Feb 2017;4(1):42-45. doi:10.1002/mdc3.12348
33. Glinzer J, Flynn É, Tampoukari E, Harpur I, Walshe M. Dysphagia Prevalence in Progressive Supranuclear Palsy: A Systematic Review and Meta-Analysis. *Dysphagia*. Dec 2024;39(6):1052-1064. doi:10.1007/s00455-024-10681-7
34. Clark HM, Tosakulwong N, Weigand SD*, et al*. Gray and White Matter Correlates of Dysphagia in Progressive Supranuclear Palsy. *Mov Disord*. Nov 2021;36(11):2669-2675. doi:10.1002/mds.28731
35. Yadav SK, Kumar R, Macey PM*, et al*. Regional cerebral blood flow alterations in obstructive sleep apnea. *Neuroscience letters*. Oct 25 2013;555:159-64. doi:10.1016/j.neulet.2013.09.033
36. Gama RL, Távora DG, Bomfim RC, Silva CE, de Bruin VM, de Bruin PFC. Sleep disturbances and brain MRI morphometry in Parkinson's disease, multiple system atrophy and progressive supranuclear palsy - a comparative study. *PARKINSONISM & RELATED DISORDERS*. MAY 2010;16(4):275-279. doi:10.1016/j.parkreldis.2010.01.002
37. Zhang Y, Ren R, Yang L, Sanford LD, Tang X. Polysomnographically measured sleep changes in idiopathic REM sleep behavior disorder: A systematic review and meta-analysis. *Sleep Med Rev*. Dec 2020;54:101362. doi:10.1016/j.smrv.2020.101362
38. Zhang H, Zhang Y, Ren R*, et al*. Polysomnographic features of idiopathic restless legs syndrome: a systematic review and meta-analysis of 13 sleep parameters and 23 leg movement parameters. *Journal of clinical sleep medicine : JCSM : official publication of the American Academy of Sleep Medicine*. Nov 1 2022;18(11):2561-2575. doi:10.5664/jcsm.10160
39. de Mendonça FMR, de Mendonça G, Souza LC*, et al*. Benzodiazepines and Sleep Architecture: A Systematic Review. *CNS & neurological disorders drug targets*. 2023;22(2):172-179. doi:10.2174/1871527320666210618103344
40. Chahine LM, Daley J, Horn S*, et al*. Association between dopaminergic medications and nocturnal sleep in early-stage Parkinson's disease. *Parkinsonism Relat Disord*. Oct 2013;19(10):859-63. doi:10.1016/j.parkreldis.2013.05.009

Figures

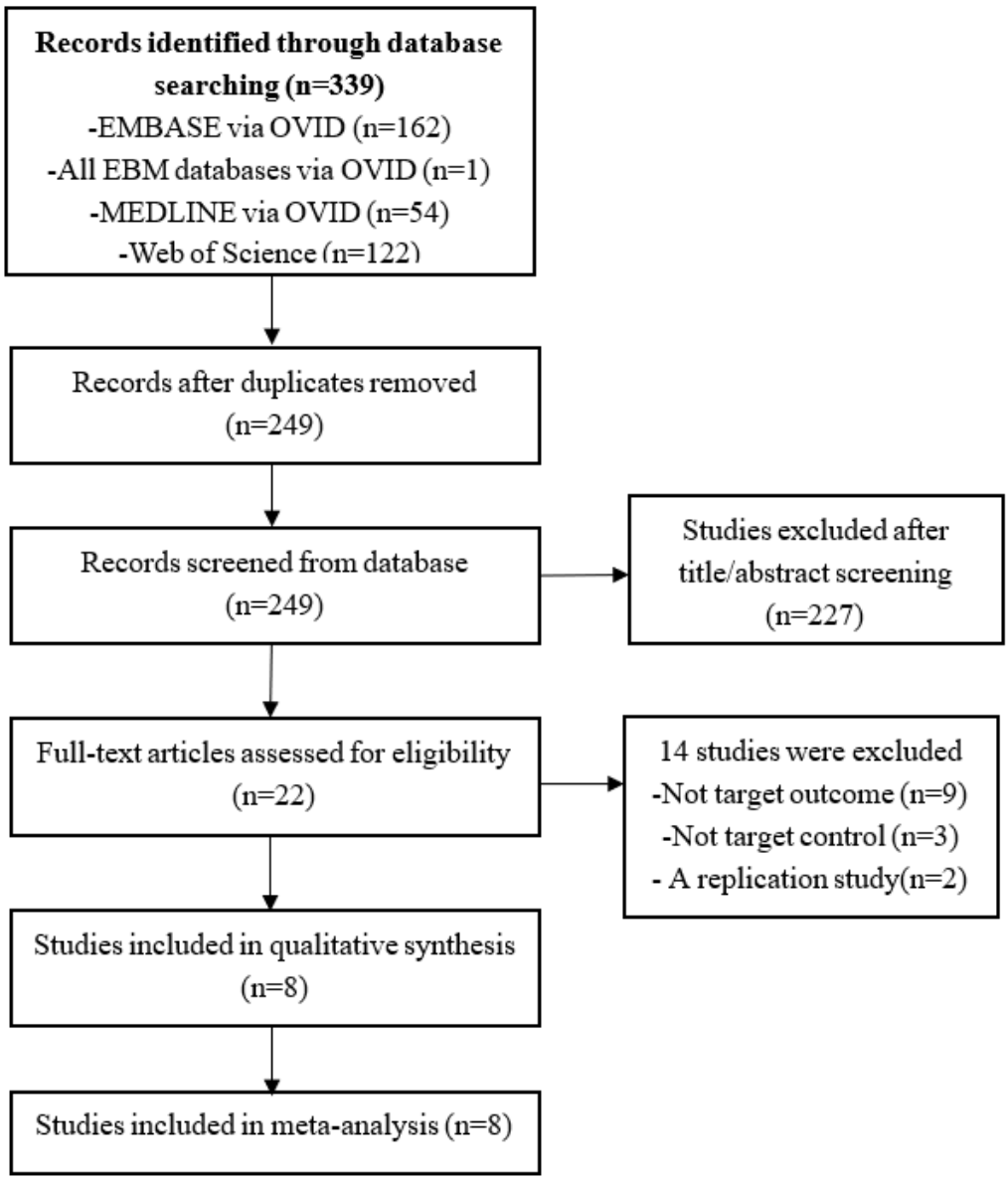


Figure 1

Flow chart used for the identification of eligible studies.

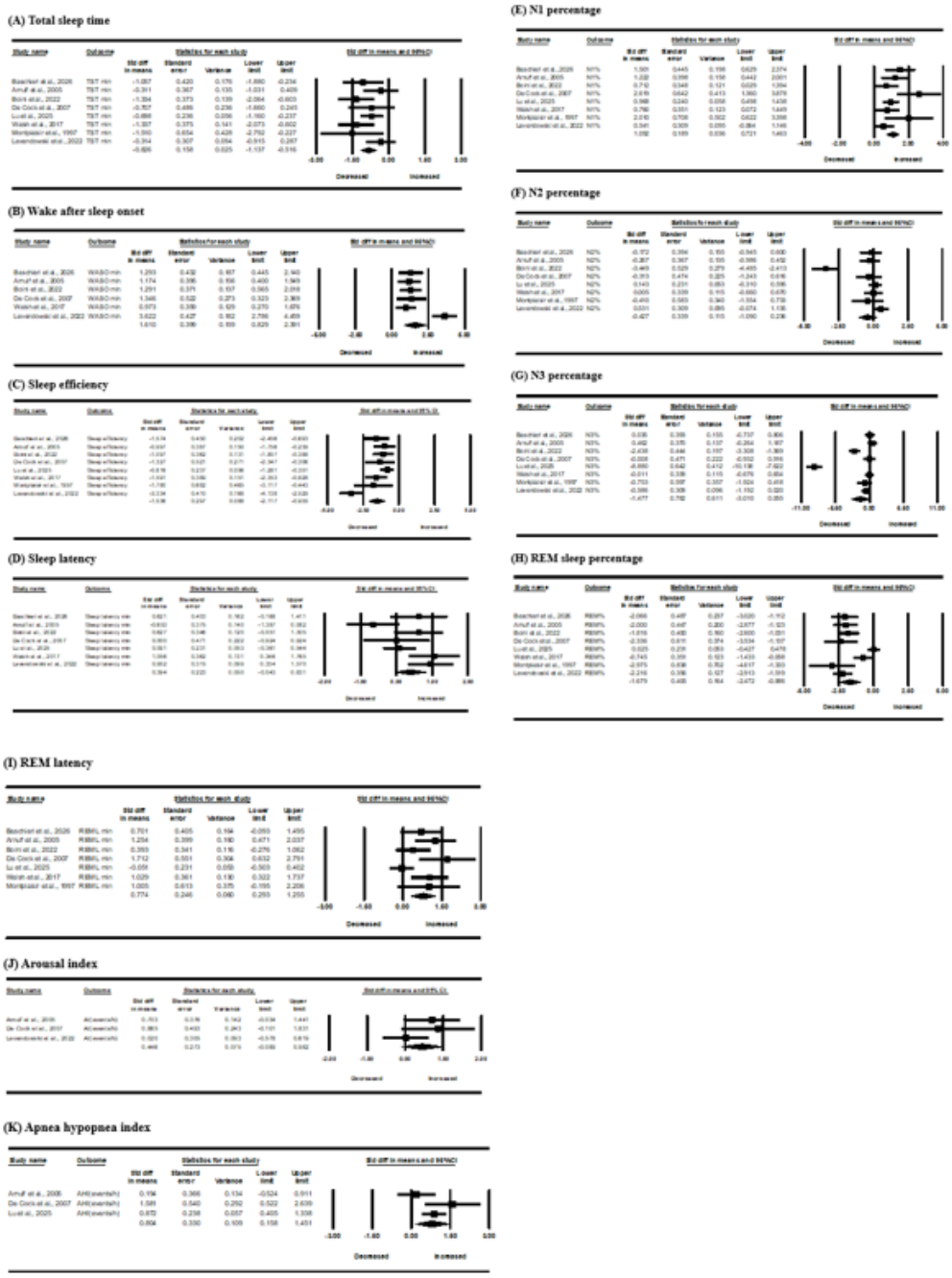


Figure 2

Forest plots comparing PSG parameters between PSP patients and controls.

Abbreviations: PSG, polysomnography; PSP, progressive supranuclear palsy; TST, total sleep time; SE, sleep efficiency; REM, rapid eye movement; WASO, wake after sleep onset; REML, REM latency; AHI, apnea-hypopnea index; AI, arousal index; SL, sleep latency.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryMaterials.docx