

RESEARCH ARTICLE



Efficacy and safety of different acupuncture therapies in treating sleep apnea syndrome: a systematic review and network meta-analysis

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ABSTRACT

Objective: To evaluate and rank the efficacy and safety of different acupuncture (AP) therapies in treating sleep apnea syndrome (SAS).

Methods: We searched PubMed, Web of Science, Cochrane Library, Embase, Wanfang Data, CNKI, CBM, and VIP for randomized controlled trials (RCTs) studying AP for SAS until April 25, 2024. Effectiveness required a >25% decrease in apnea-hypopnea index (AHI) and a >1/3 reduction in symptom scores after treatment. Secondary outcomes included AHI, lowest oxygen saturation (LSaO₂), longest apnea time (LAT), Epworth Sleepiness Scale (ESS) score, and adverse events (AEs). We performed standard pairwise meta-analyses and network meta-analyses (NMA) using Stata15.1 and RStudio4.2.3, assessed evidence quality (GRADE), and ranked treatments using SUCRA values.

Results: Network meta-analysis of 43 randomized trials (3402 SAS patients) revealed distinct efficacy profiles: Electroacupuncture (EA) was the best intervention for reducing apnea-hypopnea index (AHI) (SUCRA=86.0%), while acupoint catgut embedding (ACE) ranked highest for both shortening longest apnea time (LAT) (SUCRA=98.7%) and improving lowest oxygen saturation (LSaO₂) (SUCRA = 89.7%). For reducing daytime sleepiness (ESS), manual acupuncture combined with Chinese herbal decoction (MA+OCHD) was most effective (SUCRA = 87.6%). In terms of overall clinical effectiveness rate, manual acupuncture plus Western medicine (MA+WM) performed best (SUCRA = 79.8%). Safety analysis showed Chinese herbal decoction (OCHD) alone was associated with the fewest adverse events (SUCRA = 93.4%).

Conclusion: AP therapies are effective and safe for SAS. EA or ACE best improves breathing parameters, MA+OCHD best reduces sleepiness, and MA+WM yields the highest overall effectiveness. These findings guide SAS treatment selection.

Abbreviations: AP: Acupuncture; SAS: sleep apnea syndrome; RCTs: randomized controlled trials; AHI: apnea-hypopnea index; LSaO₂: lowest oxygen saturation; LAT: longest apnea time; ESS: Epworth Sleepiness Scale; AEs: adverse events; NMA: network meta-analyses; EA: Electroacupuncture; ACE: Acupoint catgut embedding; OSAS: Obstructive sleep apnea syndrome; CSAS: central sleep apnea syndrome

ARTICLE HISTORY

Received 8 January 2025

Revised 30 April 2025

Accepted 9 May 2025

KEYWORDS

Acupuncture; sleep apnea syndrome; systematic review; network meta-analysis (NMA); effectiveness

1. Introduction

Sleep apnea syndrome (SAS) is a common clinical sleep disorder, including obstructive sleep apnea syndrome (OSAS), central sleep apnea syndrome (CSAS), sleep-related hypoventilation disorders, and sleep-related hypoxemia, which are characterized by intermittent hypoxia, hypercapnia, desaturation of blood oxygen and sleep fragmentation caused by repeated apnea [1]. Epidemiologic research suggests that OSAS, the most common type of SAS, affects nearly one billion people worldwide [2], with a prevalence of 24% in men and 9% in women in the general 30–60-year-old group. The prevalence increases

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/07853890.2025.2527356>.

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with age and reaches 90% in men and 78% in women in the elderly group [3]. SAS can seriously affect the quality of life such as morning headaches, excessive daytime sleepiness, impaired concentration, social problems, and systemic illness, and also increase patients' psychological and financial burdens [4].

SAS, as a heterogeneous disorder, necessitates personalized therapies. Current drugs (e.g. modafinil) exhibit subtype-specific efficacy but fail to target the core pathology of upper airway neuromuscular dysfunction. Behavioral changes by health education, auxiliary devices (oral appliance and CPAP) or surgery are the major treatment means. There is a risk of teeth and facial muscle and joint discomfort caused by oral appliance or mandibular advancement appliance in some patients. The tolerance of adults to CPAP and nCPAP is low, and most patients still have sleep fragmentation after treatment [5]. Tracheotomy, uvulopalatopharyngoplasty, tonsillectomy and bariatric Surgery all carry risks of surgical failure and complications. With simple operation, fewer adverse effects than surgical treatment [6–10], acupuncture (AP) is becoming increasingly popular worldwide as an important TCM treatment method [11]. Multiple clinical trials have demonstrated that AP and moxibustion therapies (including manual AP, electroacupuncture, and acupoint application) achieve significant efficacy in improving sleep-related breathing disorders in patients with SAS [12–14]. The therapeutic mechanism is associated with stimulating relevant acupoints to activate the hypoglossal motor nucleus, thereby enhancing the contractile strength of the genioglossus and other upper airway muscles. Additionally, these therapies enhance the long-term maintenance of upper airway muscle tone during sleep, reducing the risk of airway narrowing or collapse [15].

Several systematic reviews and meta-analyses from China have assessed the efficacy of AP on SAS [16–22], and carried out statistical analyses on the total effective rate, AHI, Epworth Sleepiness Scale (ESS) score, lowest oxygen saturation (LSaO₂), longest apnea time (LAT), and S100β level.

Principles of treatment, methods of acupuncture and quantity of stimulation vary across AP therapies, and the relative effectiveness of different AP therapies on SAS deserves further exploration. Deficiencies were present in the design of previous systematic reviews and meta-analyses. The database in the most recent systematic review was established in 2023, assessed the safety and effectiveness of aps in SAS, but did not provide direct evidence that different aps are safe and effective in treating SAS [17]. Network meta-analysis (NMA) identifies the potential best choice of treatment regimen by comparing multiple treatment options in a single meta-analysis and by integrating direct and indirect evidence to compare different treatments [23]. Therefore, the efficacy and safety of different AP therapies (and their combinations) in treating SAS were assessed and compared by a systematic search for relevant data in this NMA.

2. Methods

2.1. Study design and registration

This systematic review was conducted following the PRISMA 2015 [24] and the protocol was registered with PROSPERO on June 3, 2024 (CRD42024553986).

2.2. Eligibility criteria

The inclusion criteria were established following the PICOS (Population, Intervention, Comparison, Outcome, and Study design) principle [25]:

(1) Population: patients diagnosed with SAS by PSG, without hypertension (AHI >5/night) [26]; no restriction on the duration of SAS, age, gender, ethnicity, education, and socioeconomic status; (2) Intervention: at least one type of AP therapy in the intervention group (including hand AP, moxibustion, EA, warm needling, ACE, and auricular pressure, rather than interventions without stimulating acupoints); (3) Comparison: non-AP in the control group (such as sham AP, standard care, medication, or different types of AP therapies from the intervention group); (4) Outcome: total effective rate (Total efficiency = 100% - no efficiency), AHI, LSaO₂, LAT, ESS scores, and AEs; (5) Study design: RCTs; Chinese- and English-language studies.

2.2.1. Exclusion criteria

(1) Unclear study design; (2) duplicate publications, with the same data or unavailable valid data; (3) studies with full text unavailable through various sources; (4) patients suffered from drug allergies or other serious illnesses (cancer, liver disease, or kidney disease).

2.3. Search strategy

Two reviewers (LY and GL) independently searched PubMed, Web of Science, Cochrane Library, Embase, Wanfang Data, CNKI, CBM, and VIP for Chinese- and English-language RCTs studying AP for SAS until April 25, 2024 (from inception to June 18, 2024). Medical subject headings (MeSH) plus free text words were used, including 'Acupuncture', 'Acupuncture Therapy', 'Electroacupuncture', 'Sleep Apnea Syndromes', and 'Obstructive Sleep Apnea'. [Figure 1](#) presents the search process of the PubMed and CNKI databases. [Supplementary Material 1](#) provides the search terms and strategies used in the PubMed and CNKI databases.

2.4. Study screening

The retrieved studies were imported into EndNote X9.0. After duplicate publications were removed, two reviewers (LY and GL) read the titles and abstracts, and excluded studies that did not meet the inclusion criteria. Then the full text was further read to identify eligible studies. When discrepancies arose between the two independent reviewers regarding the interpretation of the PICOS (Population, Intervention, Comparison, Outcomes, and Study Design), they were resolved through discussion with a third reviewer (CW).

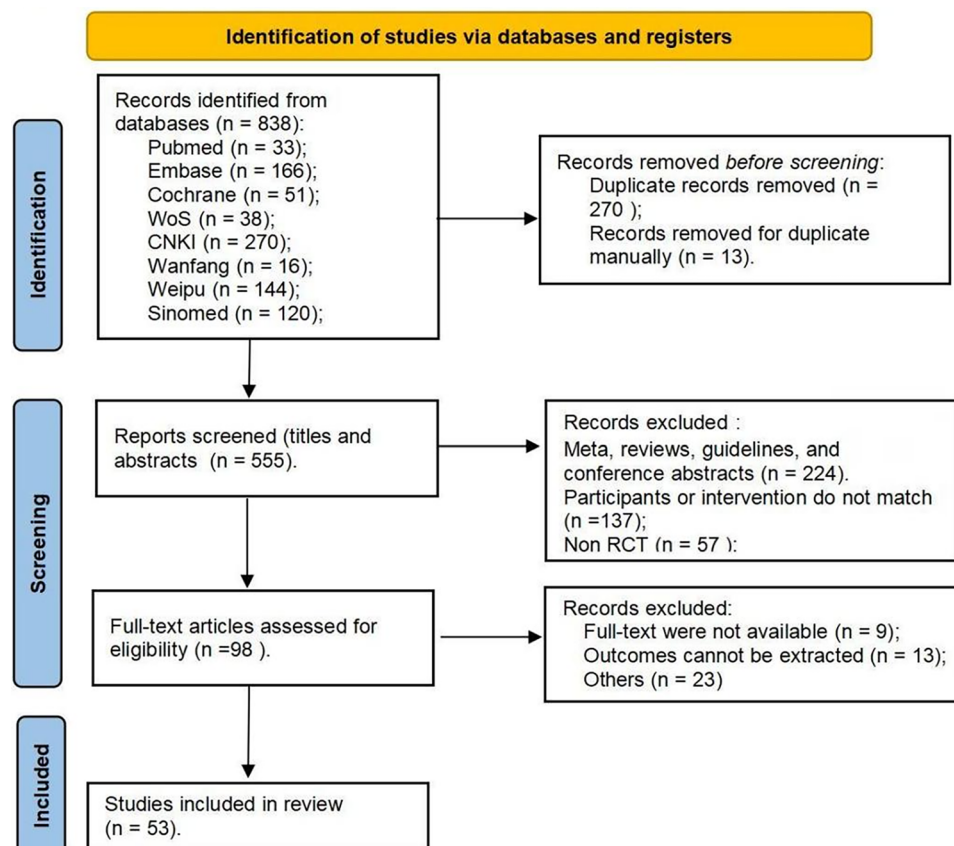


Figure 1. Flow diagram of study selection.

2.5. Data extraction and quality evaluation

Two reviewers (LY and GL) independently extracted the following data from the included studies: (1) general information (country, first author, year of publication, sample size, study type, and study design); (2) subject information (age, gender, diagnostic criteria, and pre-treatment course); (3) intervention and comparison (specific interventions); (4) baseline and post-treatment outcomes (AHI, LAT, LSaO₂, ESS, and clinical efficacy); (5) AEs. The data were extracted by one reviewer (CW) and then assessed for accuracy by the other (ZB).

The Cochrane Risk of bias tool (ROB2.0) was used to evaluate the quality of eligible studies independently by two reviewers (YD and LD). ROB2.0 criteria included five aspects: randomization sequence generation, allocation concealment, blinding, missing data, and selective reporting. Each part was graded as high risk, moderate risk, and low risk according to the risk level. When assessing the overall quality of the article, if all five items were low risk or only one item was medium risk, and the rest were low risk, the article was considered as low risk. A study was considered high-risk if four or more of the five items were medium risk or any one item was high risk. The remaining case studies were medium risk studies. Two authors independently completed the literature quality assessment, and disagreements were resolved by review and discussion with a third reviewer (CW).

2.6. Data analysis

For categorical variables, relative efficacy was measured by the risk ratio (RR) of the change score with 95% credibility interval (CrI); the mean difference (MD) of the change score with 95% CrI was used to measure the relative efficacy for continuous variables. Four Markov chains were set up for each outcome, each generating 50,000 iterations, of which 20,000 were discarded as burn-in. Brooks–Gelman–Rubin plots were used to assess the iteration convergence [27]. The probability of being the optimal intervention was calculated by SUCRA. The higher the SUCRA value, the more effective the intervention [28]. Consistency modeling was adopted when a DIC difference <5 suggested good consistency [29]. Local inconsistency between direct and indirect comparisons was assessed using the node-splitting method, and $p < 0.05$ suggested local inconsistency [30].

Publication bias was tested by comparison corrected funnel plot. Network diagrams, Comparison-adjusted funnel plots and Line plot of cumulative probability were created by Stata17.0 (StataCorp, College Station, TX, USA). Different interventions were presented as network diagrams of nodes and lines, in which the size of the nodes represented the sample size and the thickness of the lines represented the frequency of two concurrent interventions.

3. Results

3.1. Screening results

As shown in [Figure 1](#), 838 potentially relevant studies were retrieved. 283 duplicate publications were eliminated using EndNote. After reading the title and/or abstract, 224 reviews, guidelines, and conference abstracts were excluded, 176 were excluded due to non-matched participants or intervention, and 57 non-RCTs were excluded. Then the remaining 98 studies were further assessed for eligibility by examining their full text, of which nine were excluded due to unavailability of full text, and 46 were excluded due to lack of data. Finally, 43 eligible studies were included [10,13,14,31–70].

3.2. Study characteristics

The included studies were published in 2008–2024, involving 3402 patients. The sample size was 20 at least [10] and 172 at most [51]. The subjects were OSAHS patients in 41 studies and SAS patients in two studies, with a mean age of 3–84.65 years. 40 studies were conducted in China [13,31–45,47–49], and three in Brazil [10,14,70]. Filiform needle AP was performed in 33 studies [10,13,31–33,35,37–39,42,43,46–49,51–57,59,61–70], EA in seven studies [10,14,34,36,40,41,60], and ACE in four studies [44,45,50,58]. AHI

was reported in 40 studies [10,13,14,31–35,37–45,47–55,57–61,63–70], LAT in 14 studies [31,34,43,45,49–51,57,59,60,67,69,70], LSaO₂ in 29 studies [13,14,31,34–39,42–44,46,48–54,57,58,60,62,63,65–67,69], ESS in 21 studies [10,14,34,35,38,39,41–43,47,49,51,53,55,58,59,62,65,68–70], clinical efficacy in 23 studies [13,32,35,37,38,43,47,48,51,53,54,57–60,62–66,68,69], and AEs in 9 studies [33,34,41,48,49,56,59,65,67,71–78] (Table 1).

3.3. Assessment of risk of bias

Five studies had some risk of randomization bias due to non-random allocation order and unequal baseline between groups [32,40,45,48,64]. Forty studies had some risk of bias in the intended interventions because a per-protocol analysis rather than a heterogeneous analysis was utilized for the assessment of interventions [13,31–45,47–69]. Five studies had a certain risk of outcome data missing bias due to incomplete outcome data [42,48,61,65,66]. Forty studies may have outcome measurement bias because the outcome measures were known to the outcome measures [13,31–45,47–69] (Table 2). The methodological quality of all the studies included in this review was considered to be moderate. Therefore, none of the studies were excluded after the risk of bias assessment.

3.4. NMA results

3.4.1. Apnea-hypopnea index

The efficacy of eight AP therapies (MA, EA, WM, MA+WM, OCHD, MA+OCHD, ACE, and PLC) on AHI in SAS patients was reported in 40 studies [10,13,14,31–35,37–45,47–55,57–61,63–70]. All results are presented in Figures 2–4. As shown in the eight triangular closed loops (Figure 2A), the connecting lines indicated the direct comparison of interventions, the thickness of the lines represented the number of studies, and the size of the nodes represented the sample size. The results of the inconsistency test show no inconsistencies (Figure 3). The NMA results revealed that EA (MD=−9.80; 95% CrI [−16.89, −2.74]) and MA (MD=−6.29; 95% CrI [−10.55, −2.06]) significantly reduced AHI compared with PLC (Figure 2B). According to the cumulative probability ranking chart and the area under the SUCRA curve ranking table, it can be concluded that EA (SUCRA = 86.0%) was the best intervention to reduce AHI, followed by MA (SUCRA = 66.7%) and ACE (SUCRA = 62.1%) (Figure 4). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row (Figure 2B).

3.4.2. Longest apnea time

The efficacy of six AP therapies (MA, EA, OCHD, MA+OCHD, ACE, and PLC) on LAT in SAS patients was reported in 14 studies [31,34,43,45,49–51,57,59,60,67,69,70]. All results are presented in Figures 5–7. As shown in the five triangular closed loops (Figure 5A), the connecting lines indicated the direct comparison of interventions, the thickness of the lines represented the number of studies, and the size of the nodes represented the sample size. The results of the inconsistency test show no inconsistencies (Figure 6). The NMA results revealed that ACE (MD=−11.58; 95% CrI [−15.49, −7.60]), EA (MD=−6.58; 95% CrI [−11.77, −2.04]), and MA (MD=−4.14; 95% CrI [−7.85, −0.33]) significantly reduced LAT compared with PLC. ACE (MD=−16.08; 95% CrI [−22.26, −8.17]), EA (MD=−11.14; 95% CrI [−18.07, −2.99]), MA (MD=−8.61; 95% CrI [−13.2, −2.51]), and MA+OCHD (MD=−8.10; 95% CrI [−14.36, −0.97]) significantly reduced LAT compared with OCHD. ACE (MD=−7.92; 95% CrI [−14.00, −1.36]) significantly reduced LAT compared with MA+OCHD. ACE (MD=−7.45; 95% CrI [−12.91, −2.00]) significantly reduced LAT compared with MA (Figure 5B). According to the ranking chart of cumulative probability and the ranking table of area under the SUCRA curve, it can be concluded that ACE (SUCRA = 98.4%) was the best intervention to reduce LAT, followed by EA (SUCRA = 74.5%) and MA (SUCRA = 54.2%) (Figure 7). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row (Figure 5B).

3.4.3. LSaO₂

The efficacy of eight AP therapies (MA, EA, OCHD, MA+OCHD, WM, MA+WM, ACE, and PLC) on LSaO₂ in SAS patients was reported in 29 studies [13,14,31,34–39,42–44,46,48–54,57,58,60,62,63,65–67,69]. All

Table 1. Basic characteristics of included studies.

No.	Author (Year)	Nationality	Participant	Diagnostic criteria	Sample size (n)		Age (Years)		Gender (Men/Women)		Intervention		Outcome
					Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	
1	Chen et al. (2008)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Draft) [71]	44	22	55.44 ± 11.04	56.73 ± 10.21	28/16	16/6	MA	PLC	AHI; LAT; LSaO ₂
2	Chen et al. (2014)	China	SAS	Diagnostic Basis and Efficacy Evaluation Criteria for Obstructive Sleep Apnea Hypopnea Syndrome and Indications for Uvulopalatopharyngoplasty (Hangzhou) [72]	40	40	62.5 (43–75)	60.9 (43–75)	26 /14	24/16	MA+WM	WM	Clinical effects; AHI
3	Zhang et al. (2014)	China	OSAHS	Jia JP. Neurology[M]. Beijing: People's Medical Publishing House, 2011:414.	45	45	48.45 ± 9.76	51.96 ± 9.87	40/5	38/7	MA	PLC	AHI; AE
4	Song et al. (2015)	China	OSAHS	Diagnosis of stroke with OSAHS;	36	34	53.17 ± 10.20	52.71 ± 11.26	24/12	23/11	EA	PLC	AHI; LAT; LSaO ₂ ; ESS; AE
5	Wang (2015)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	63	63	64 ± 13	63 ± 14	35/28	35/28	MA	PLC	Clinical effects; AHI; LSaO ₂ ; ESS
6	Zhang (2016)	China	OSAHS	Diagnostic Basis and Efficacy Evaluation Criteria for Obstructive Sleep Apnea Hypopnea Syndrome and Indications for Uvulopalatopharyngoplasty (Hangzhou) [71]	50	50	64.75 ± 5.42	62.43 ± 6.01	27/23	30/20	EA	PLC	LSaO ₂
7	Ding et al. (2017)	China	OSAHS	Draft of Guidelines for the Diagnosis and Treatment of Pediatric Sleep Apnea Hypopnea Syndrome (Urumqi) [74]	28	28	Ave. 4.8	Ave. 4.6	15/13	13/15	MA+WM	PLC	AHI; LSaO ₂ ; Clinical effects
8	Li et al. (2017)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	50	50	50.7 ± 3.5	51.2 ± 3.3	29/21	27/23	MA	PLC	AHI; LSaO ₂ ; ESS; Clinical effects
9	Lv (2017)	China	OSAHS	Diagnosis of stroke with OSAHS;	40	39	64.8 ± 11.4	65.2 ± 11.5	23/17	21/18	MA	PLC	AHI; LSaO ₂ ; ESS
10	Tian et al. (2017)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Draft) [71]	30	30	48.25 ± 1.77	43.58 ± 1.88	17/13	16/14	EA	PLC	AHI
11	Huang et al. (2018)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	28	28	63.6 ± 7.0	61.3 ± 9.1	19/9	17/11	EA	PLC	AHI; ESS; AE
12	Zheng et al. (2018)	China	OSAHS	Management of Obstructive Sleep Apnea in Adults: A Clinical Practice Guideline From the American College of Physicians [75]	18	19	56.54 ± 14.98	56.54 ± 14.98	14/4	15/4	MA+OCHD	OCHD	AHI; LSaO ₂ ; ESS
13	Zhang et al. (2019)a	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	41	41	56.3 ± 11.3	55.0 ± 11.8	35; 6	34; 7	MA+OCHD	PLC	AHI; LSaO ₂ ; ESS; LAT; Clinical effects
14	Zhang et al. (2019)		OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	73	73	59. 34 ± 3. 71	58.98 ± 3.47	38/35	40/33	ACE	PLC	AHI; LSaO ₂
15	Dou (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	55	55	52.28 ± 3.12	52.36 ± 3.15	41/14	43/12	ACE	PLC	AHI; LAT

(Continued)

Table 1. Continued.

No.	Author (Year)	Nationality	Participant	Diagnostic criteria	Sample size (n)		Age (Years)		Gender (Men/Women)		Intervention		Outcome
					Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	
16	Li et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	47	47	49.72±5.34	49.52±5.19	30/17	17/20	MA	PLC	AHI; LSaO ₂ ; ESS; LAT; Clinical effects
17	Liang et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	30	30	51.00±9.05	49.33±9.52	15/15	15/15	MA	PLC	Clinical effects; AHI; ESS
18	Lu et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	26	28	68.41±4.57	67.38±4.48	17/15	18/16	MA+OCHD	OCHD	AHI; LSaO ₂ ; Clinical effects; AE
19	Ma et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	33	35	60.33±9.08	62.09±8.83	22/11	20/15	MA+OCHD	PLC	AHI; LSaO ₂ ; ESS; LAT; AE
20	Wang et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	45	45	42.48±10.31	43.51±9.47	24/21	25/20	ACE	PLC	AHI; LAT; LSaO ₂
21	Yuan et al. (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	86	86	53.91±5.32	53.87±5.25	49/37	48/38	MA	PLC	Clinical effects; AHI; LAT; LSaO ₂
22	Zhao (2020)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Draft) [71]	36	36	51.50±3.70	50.50±3.50	21/15	22/14	MA+OCHD	PLC	AHI; LSaO ₂
23	Zhou et al. (2021)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	24	35	47.00±13.00	46.00±11.00	27/7	26/9	MA	PLC	Clinical effects; AHI; LSaO ₂ ; ESS
24	Yu et al. (2021)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	30	30	3.00–6.00	3.00–6.00	14/16	14/16	MA	PLC	AHI; LSaO ₂ ; Clinical effects
25	Chen (2022)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	35	35	54.52±3.68	55.57±3.42	20/15	19/16	MA+OCHD	PLC	ESS; AHI
26	He (2022)	China	OSAHS	Post-cerebral infarction sleep apnea	61	61	84.65±10.34	84.68±10.65	31/30	29/32	MA	PLC	AE
27	Min et al. (2022)	China	SAS	Ministry of Health of the People's Republic of China. Guiding Principle of Clinical Research on New Drugs of Traditional Chinese Medicine[S]. Ministry of Health of the People's Republic of China, 1990:158.	30	30	46.11±11.46	45.56±13.37	16/14	18/12	MA	OCHD	Clinical effects; AHI; LAT; LSaO ₂
28	Peng et al. (2022)	China	OSAHS	Guidelines for Primary Diagnosis and Treatment of Obstructive Sleep Apnea in Adults (Practice Edition-2018) [76]	30	30	30.7±6.7	30.5±6.1	24/6	23/7	ACE	PLC	Clinical effects; AHI; LSaO ₂ ; ESS
29	Qi et al. (2022)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	51	51	52.18±4.30	52.24±4.23	36/15	16/35	MA+OCHD	PLC	Clinical effects; AHI; LAT; ESS; AE
30	Shen et al. (2022)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	50	50	47.46±3.01	47.03±3.17	28/22	26/24	EA	PLC	Clinical effects; AHI; LSaO ₂ ; LAT

(Continued)

Table 1. Continued.

No.	Author (Year)	Nationality	Participant	Diagnostic criteria	Sample size (n)		Age (Years)		Gender (Men/Women)		Intervention		Outcome
					Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control	
31	Wei et al. (2022)	China	OSAHS	Guidelines for Primary Diagnosis and Treatment of Obstructive Sleep Apnea in Adults (Practice Edition-2018) [76]	48	48	50.00 ± 8.00	49.00 ± 7.00	24/24	25/23	MA	PLC	AHI
32	Ye et al. (2022)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Draft) [71]	38	38	52.00 ± 11.00	54.00 ± 10.00	35/3	34/4	MA+OCHD	OCHD	Clinical effects; LSAO ₂ ; ESS
33	Huang et al. (2023)	China	OSAHS	Guidelines for Primary Diagnosis and Treatment of Obstructive Sleep Apnea in Adults (Practice Edition-2018) [76]	33	34	45.80 ± 8.70	46.30 ± 9.10	17/16	16/18	MA+WM	WM	Clinical effects; AHI; LSAO ₂
34	Lu et al. (2023)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Primary Edition) [77]	54	42	5.87 ± 2.16	6.28 ± 2.67	31; 23	28; 14	MA+WM	WM	Clinical effects; AHI
35	Ma et al. (2023)	China	OSAHS	Guidelines for Primary Diagnosis and Treatment of Obstructive Sleep Apnea in Adults (Practice Edition-2018) [76]	42	45	45.13 ± 11.58	46.32 ± 12.06	32/10	34/11	MA+OCHD	OCHD	Clinical effects; AHI; LSAO ₂ ; ESS; AE
36	Tian et al. (2023)	China	SAS	Snow W, Li DQ. Ballenger's otorhinolaryngology head and neck surgery. Beijing: People's Med Publish House, 2012. [78]	38	37	7.03 ± 1.22	7.19 ± 1.08	23/15	21/16	MA+OCHD	PLC	AHI; LSAO ₂ ; Clinical effects
37	Yang et al. (2023)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	30	30	60.00 ± 5.00	59.00 ± 6.00	18/12	20/10	MA	PLC	AHI; LAT; LSAO ₂ ; AE
38	Zhang et al. (2023)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (Draft) [71]	52	52	49.81 ± 6.77	50.31 ± 6.84	27/25	24/28	MA+OCHD	OCHD	Clinical effects; AHI; ESS
39	Liu et al. (2024)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	34	30	34.85 ± 5.54	34.52 ± 5.15	19/ 15	20; 10	MA+OCHD	OCHD	Clinical effects; AHI; LAT; LSAO ₂ ; ESS
40	Freire et al. (2007)	Brazil	OSAHS	Diagnosis of obstructive sleep apnea by PSG, AHI > 15/h, <30/h (moderate OSAS)	12	12	54.00 (51.0–63.0)	53.00 (49.0–63.0)	–	–	MA	PLC	ESS; AHI; LAT
41	Freire et al. (2015)	Brazil	OSAHS	Diagnosis of obstructive sleep apnea by PSG, AHI > 15/h, <30/h (moderate OSAS)	10	10	57.70 (44.0–68.0)	54.80 (35.0–71.0)	–	–	MA	EA	AHI; ESS
42	Silva et al. (2020)	Brazil	OSAHS	Diagnosis of obstructive sleep apnea by PSG, AHI > 15/h, <30/h (moderate OSAS)	20	24	57.30 ± 5.80	56.80 ± 5.20	6/14	9/15	EA	PLC	AHI; ESS; LSAO ₂
43	Zhang et al. (2021)	China	OSAHS	Guidelines for the Diagnosis and Treatment of Obstructive Sleep Apnea Hypopnea Syndrome (2011 Revision) [73]	44	44	56.80 ± 5.30	57.40 ± 6.40	24/20	19/25	MA+WM	WM	Clinical effects; AHI; LSAO ₂

Abbreviations: OSAHS: obstructive sleep apnea hypopnea syndrome; SAS: sleep apnea syndrome; MA: manual acupuncture; EA: electroacupuncture; MA+WM: manual acupuncture plus Western medicine; WM: Western medicine; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction; AHI: apnea-hypopnea index; LSAO₂: lowest oxygen saturation; LAT: longest apnea time; ESS: Epworth Sleepiness Scale; AE: Adverse event.

Table 2. Quality evaluation.

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall
Chen et al. (2008)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Chen et al. (2014)	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang et al. (2014)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Song et al. (2015)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Wang (2015)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang(2016)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Ding et al. (2017)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Li et al. (2017)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Ly(2017)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Tian et al. (2017)	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Huang et al. (2018)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zheng et al. (2018)	Low risk	Moderate risk	Moderate risk	Moderate risk	Low risk	Moderate risk
Zhang et al. (2019)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang et al. (2019)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Dou (2020)	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Li et al. (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Liang et al. (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Lu et al. (2020)	Moderate risk	Moderate risk	Moderate risk	Moderate risk	Low risk	Moderate risk
Ma et al. (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Wang et al. (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Yuan et al. (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhao (2020)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhou et al. (2021)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Yu et al. (2021)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Chen (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
He(2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Min et al. (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Peng et al. (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Qi et al. (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Shen et al. (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Wei et al. (2022)	Low risk	Moderate risk	Moderate risk	Moderate risk	Low risk	Moderate risk
Ye et al. (2022)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Huang et al. (2023)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Lv et al. (2023)	Moderate risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Ma et al. (2023)	Low risk	Moderate risk	Moderate risk	Moderate risk	Low risk	Moderate risk
Tian et al. (2023)	Low risk	Moderate risk	Moderate risk	Moderate risk	Low risk	Moderate risk
Yang et al. (2023)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Zhang et al. (2023)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Liu et al. (2024)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk
Freire et al. (2007)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Freire et al. (2015)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Silva et al. (2020)	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Zhang et al. (2021)	Low risk	Moderate risk	Low risk	Moderate risk	Low risk	Moderate risk

results are presented in [Figures 8–10](#). As shown in the five triangular closed loops ([Figure 8A](#)), the connecting lines indicated the direct comparison of interventions, the thickness of the lines represented the number of studies, and the size of the nodes represented the sample size. The results of the inconsistency test show no inconsistencies ([Figure 9](#)). The NMA results revealed that LSaO₂ was significantly increased by ACE (MD=7.24; 95% CrI [3.09, 11.33]), EA (MD=4.60; 95% CrI [0.88, 8.23]), MA (MD=4.26; 95% CrI [2.10, 6.43]), and MA+OCHD (MD=5.62; 95% CrI [2.86, 8.421]) compared with PLC, and also significantly increased by ACE (MD=6.45; 95% CrI [1.14, 11.80]) and MA+OCHD (MD=4.83; 95% CrI [2.05, 7.74]) compared with OCHD ([Figure 8B](#)). According to the cumulative probability ranking chart and the area under the SUCRA curve ranking table, it can be concluded that ACE (SUCRA = 89.7%) was the best intervention to improve LSaO₂, followed by MA+OCHD (SUCRA = 77.40%) and EA (SUCRA = 64.4%) ([Figure 10](#)). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row ([Figure 8B](#)).

3.4.4. Epworth Sleepiness Scale

Twenty-one studies [10,14,34,35,38,39,41–43,47,49,51,53,55,58,59,62,65,68–70] reported the efficacy of eight AP therapies (MA, EA, OCHD, MA+OCHD, WM, MA+WM, ACE, and PLC) on ESS scores in SAS patients. All results are presented in [Figures 11–13](#). As shown in the five triangular closed loops ([Figure 11A](#)), the connecting lines indicated the direct comparison of interventions, the thickness of the lines

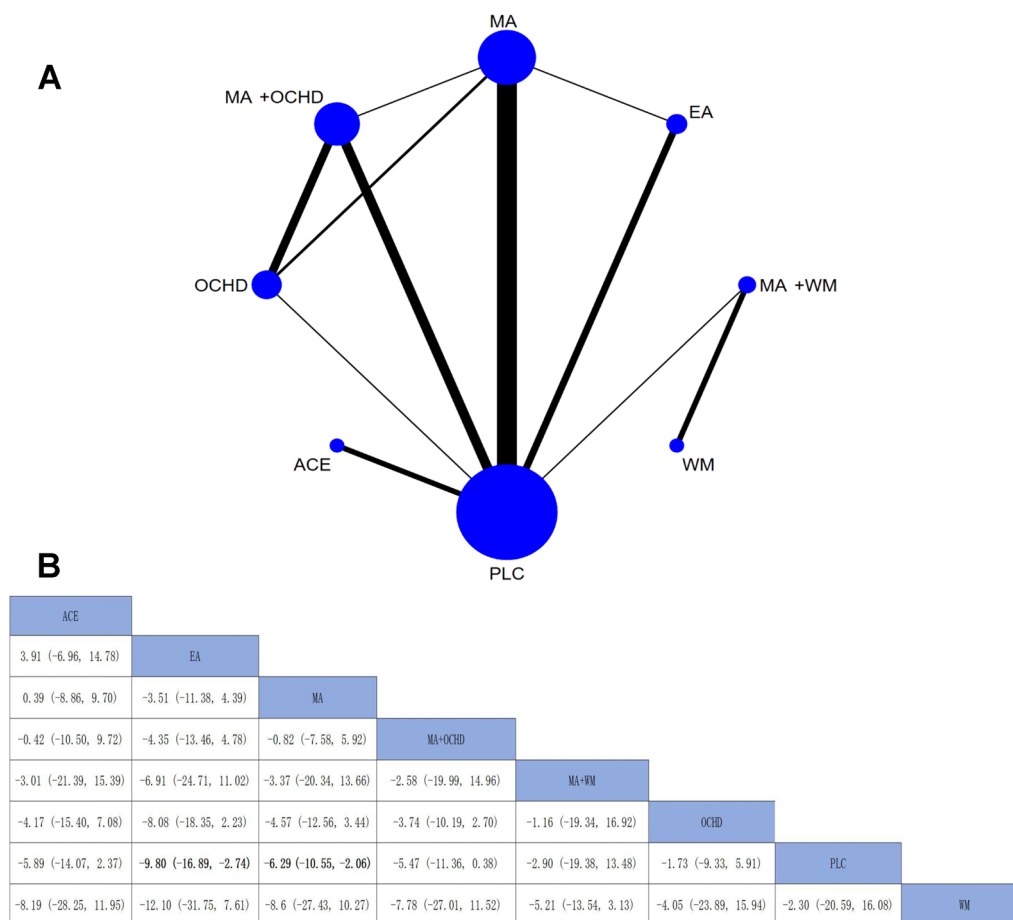


Figure 2. Network diagram and NMA results. Estimates are described by mean difference (MD) and 95% credibility interval (CrI; in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; MA+WM: manual acupuncture plus Western medicine; WM: Western medicine; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

represented the number of studies, and the size of the nodes represented the sample size. The results of the inconsistency test indicate the presence of local inconsistencies (Figure 12). The NMA results revealed that the ESS scores were significantly reduced by MA (MD = -2.24; 95% CrI [-3.44, -1.10]) and MA+OCHD (MD = -3.13; 95% CrI [-4.47, -1.78]) compared with PLC, and also significantly reduced by MA+OCHD (MD = -2.52; 95% CrI [-3.91, -1.13]) compared with OCHD (Figure 11B). According to the cumulative probability ranking chart and the area under the SUCRA curve ranking table, it can be concluded that MA+OCHD (SUCRA = 90.9%) was the best intervention to reduce ESS score, followed by MA (SUCRA = 68.0%) and ACE (SUCRA = 55.0%) (Figure 13). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row (Figure 11B).

3.4.5. Total effective rate

Twenty-three studies [13,32,35,37,38,43,47,48,51,53,54,57–60,62–66,68,69] reported the total effective rate of eight AP therapies (MA, EA, OCHD, MA+OCHD, WM, MA+WM, ACE, and PLC) in SAS patients. The global heterogeneity test revealed an I^2 -statistic of 0% across all included studies. All results are presented in Figures 14–16. The five triangular closed loops are shown in Figure 14A. The results of the inconsistency test show no inconsistencies (Figure 15). The NMA results revealed that the total effective rate was significantly raised by MA (RR = 3.41; 95% CrI [1.73, 6.76]), MA+OCHD (RR = 5.95; 95% CrI [2.36, 16.4]), and MA+WM (RR = 8.14; 95% CrI [1.06, 74.41]) compared with PLC, significantly raised by MA+WM (RR = 5.04; 95% CrI [1.89, 14.15]) compared with WM, and also significantly raised by MA+OCHD (RR =

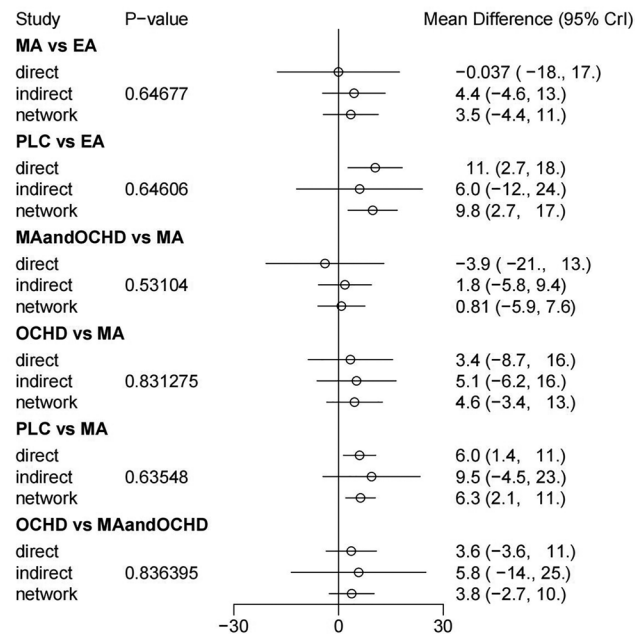


Figure 3. Results of inconsistent tests. Note: Consistency tests were used to assess the internal consistency of the data. Mean difference (MD) and 95% confidence interval (CrI; In parentheses). $p > 0.05$ indicated that there was no inconsistency of outcome, and $p < 0.05$ indicated that there was no regional inconsistency of outcome. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; OCHD: oral Chinese herbal decoction; MA and OCHD: manual acupuncture plus oral Chinese herbal decoction.

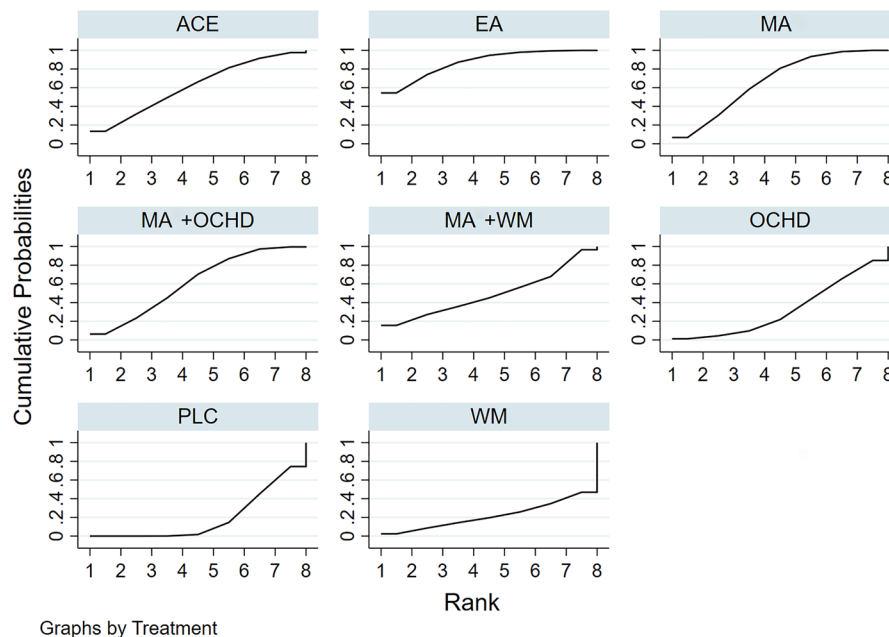


Figure 4. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve AHI in SAS patients. MA: manual acupuncture; EA: electroacupuncture; MA+WM: manual acupuncture plus Western medicine; WM: Western medicine; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

3.72; 95% CrI [1.54, 10.35]) compared with OCHD (Figure 14B). According to the cumulative probability ranking chart and the area under the SUCRA curve ranking table, it can be concluded that MA+WM (SUCRA = 79.8%) had the highest total effective rate, followed by MA+OCHD (SUCRA = 75.1%) and ACE

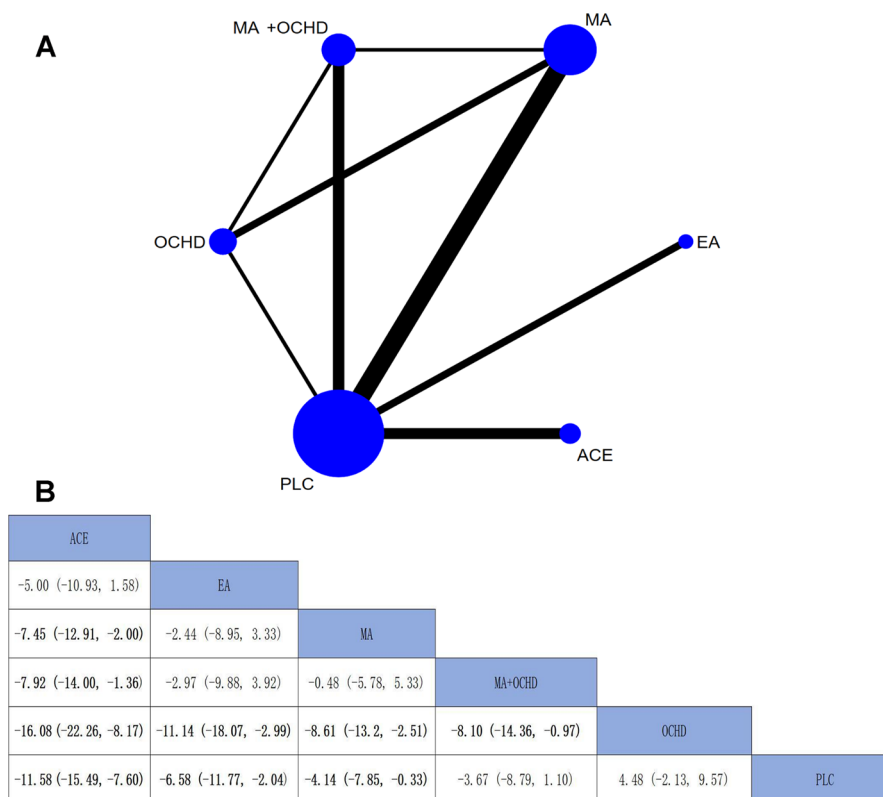


Figure 5. Network diagram and NMA results. (A) Network diagram of LAT (s); (B) Relative impact of different AP therapies on LAT. Estimates are described by MD and 95% CrI (in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; OCHD: oral Chinese herbal decoction; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

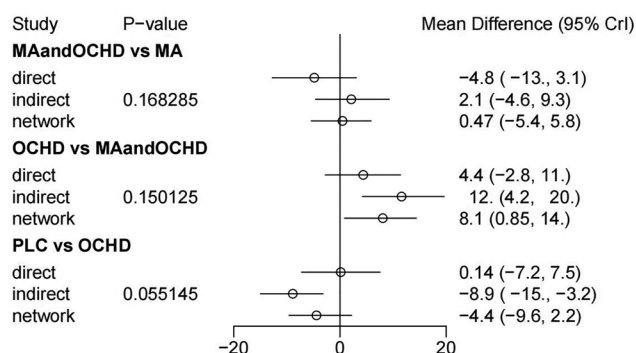


Figure 6. Results of inconsistent tests. Note: Consistency tests were used to assess the internal consistency of the data. Mean difference (MD) and 95% confidence interval (CrI; In parentheses). $p > 0.05$ indicated that there was no inconsistency of outcome, and $p < 0.05$ indicated that there was no regional inconsistency of outcome. MA: manual acupuncture; PLC: placebo; OCHD: oral Chinese herbal decoction; MA and OCHD: manual acupuncture plus oral Chinese herbal decoction.

(SUCRA = 68.7%) (Figure 16). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row (Figure 14B).

3.4.6. Aes

The AEs of five AP therapies (MA, EA, OCHD, MA+OCHD, and PLC) in SAS patients were analyzed in nine studies [33,34,41,48,49,56,59,65,67]. All results are presented in Figures 17 and 18. No closed loops were

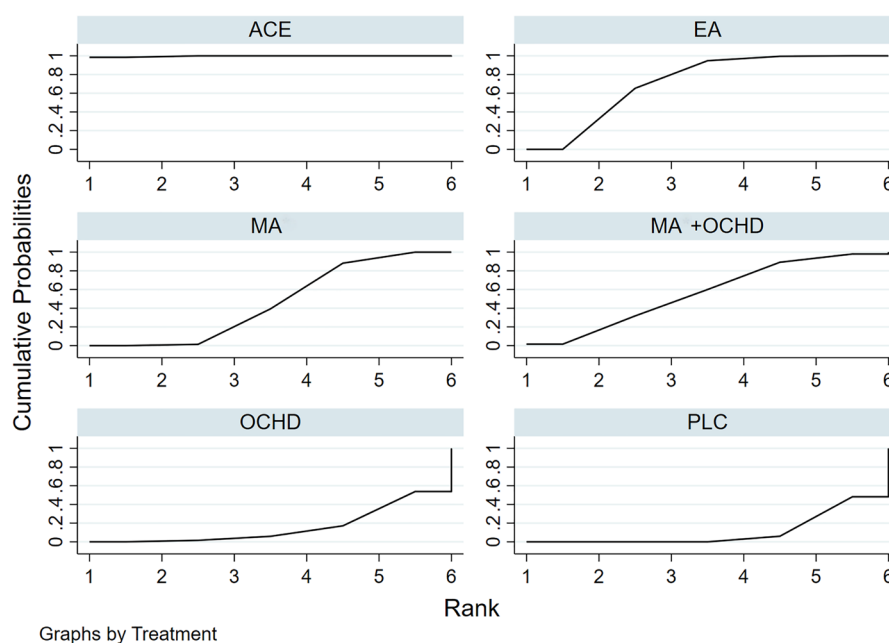


Figure 7. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve LAT in SAS patients. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

generated (Figure 17A). Different interventions displayed no statistically significant differences. The results of the inconsistency test show no inconsistencies. The NMA results are shown in Figure 17B. According to the cumulative probability ranking chart and the area under the SUCRA curve ranking table, it can be concluded that OCHD (SUCRA = 93.4%) has the best safety, followed by MA+OCHD (SUCRA = 62.3%) and MA (SUCRA = 44.4%) (Figure 18). Numbers in league tables indicate effect sizes and confidence intervals for interventions in the column versus row (Figure 17B).

3.4.7. Publication bias

Possible publication bias could be detected by funnel plots, and the left-right symmetric plot suggested no significant publication bias. Funnel plots were created for post-treatment AHI, LAT, LSaO₂, ESS, total effective rate, and AEs (Figure 19). It was found that no significant publication bias was present for post-treatment AHI, LAT, LSaO₂, and ESS, while the total effective rate and AEs had publication bias.

4. Discussion

Characterized by recurrent apnea leading to intermittent hypoxia and hypercapnia with decreased oxygen saturation and sleep fragmentation, sleep apnea syndrome (SAS) is a clinical sleep disorder of high prevalence [1]. Insufficient tension of the upper airway musculature to maintain airway patency is a common cause of SAS. In the case of upper airway relaxation, the anatomical structure of the upper airway will be pulled into the airflow as the diaphragm descends, impeding inspiratory airflow [79]. The risk of upper airway narrowing or collapse is increased due to obesity, craniofacial changes, alterations in upper airway muscle function, pharyngeal neuropathy, and fluid shifts in the neck [80,81]. As a 'simple, convenient, efficient and inexpensive' method, AP can effectively correct hypoventilation in SAS patients by stimulating local muscles to promote muscle contraction and relieve tissue edema [53], and can also play a role by regulating immune stress response and reducing tissue damage [82]. Following a systematic search, we analyzed all available evidence from 43 RCTs to compare the effects of different AP therapies on sleep-related breathing disorders, oxygen saturation, degree of sleepiness, clinical efficacy and AEs in SAS patients. The results revealed that EA was the best intervention in reducing AHI, ACE was the best intervention in reducing LAT, ACE was

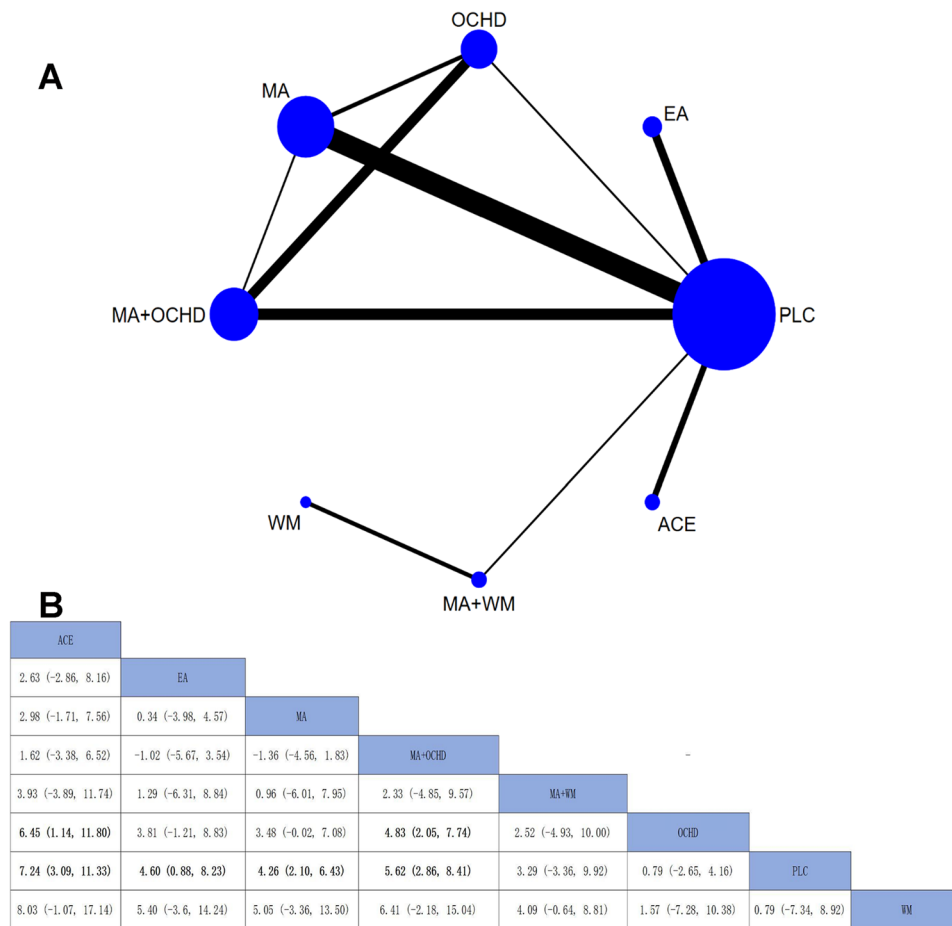


Figure 8. Network diagram and NMA results. (A) Network diagram of LSaO₂ (%); (B) Relative impact of different AP therapies on LSaO₂. Estimates are described by MD and 95% CrI (in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; WM: Western medicine; OCHD: oral Chinese herbal decoction; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction; MA+WM: manual acupuncture plus Western medicine.

most effective in increasing LSaO₂, and MA+OCHD was most effective in reducing daytime sleepiness. Moreover, MA+WM achieved the highest total effective rate, and MA+WM had the better safety profile.

Abnormal airway anatomy is the root cause of SAS. Anatomically, the hypoglossal nerve, the glossopharyngeal nerve, and their branches are below the Yamen, Lianquan, and Tiantu acupoints, so AP at paraglossal and pharyngeal acupoints can significantly alleviate airway stenosis. Polysomnogram (PSG) monitoring is the gold standard for SAS diagnosis. The higher the AHI, the more severe the disease [83]. Four studies showed that AHI was significantly lower in the AP group than in the routine therapy group [16,17,19–22]. One study showed that AHI significantly declined in the MA and EA groups compared with the routine therapy group [18]. In this NMA, it was found that EA, MA, and ACE were all significantly effective in reducing AHI in SAS patients. EA was superior to other AP therapies in ameliorating AHI in SAS patients. The possible reason is that EA can enhance the physiological contractility and toughness of the hypoglossal nerves and muscles at Lianquan acupoint by AP and continuous low-frequency electrical stimulation, thereby achieving passive protrusive movement of upper airway dilator muscles such as the genioglossus, and effective retrolingual airway patency, and ultimately reducing AHI [41,84]. LAT prolongation and LSaO₂ reduction are the main manifestations of SAS. One study revealed that LAT was significantly shorter in the AP group than in the routine therapy group [16]. Five studies revealed that

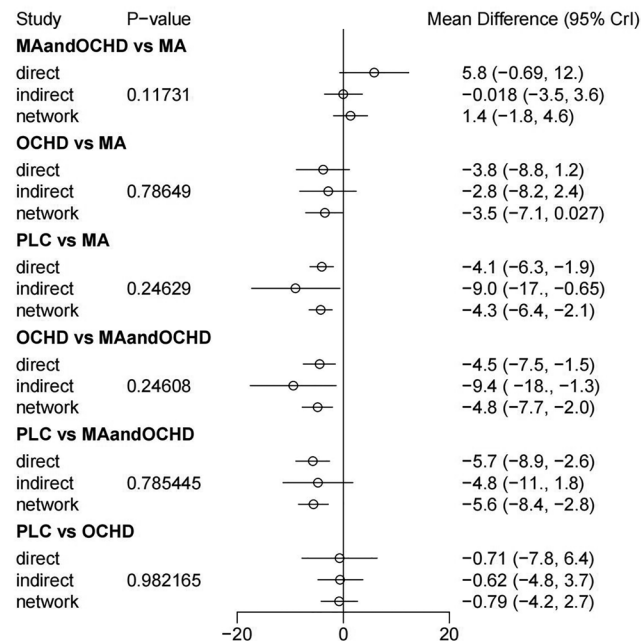


Figure 9. Results of inconsistent tests. Consistency tests were used to assess the internal consistency of the data. Mean difference (MD) and 95% confidence interval (CrI; In parentheses). $p > 0.05$ indicated that there was no inconsistency of outcome, and $p < 0.05$ indicated that there was no regional inconsistency of outcome. MA: manual acupuncture; PLC: placebo; OCHD: oral Chinese herbal decoction; MA and OCHD: manual acupuncture plus oral Chinese herbal decoction.

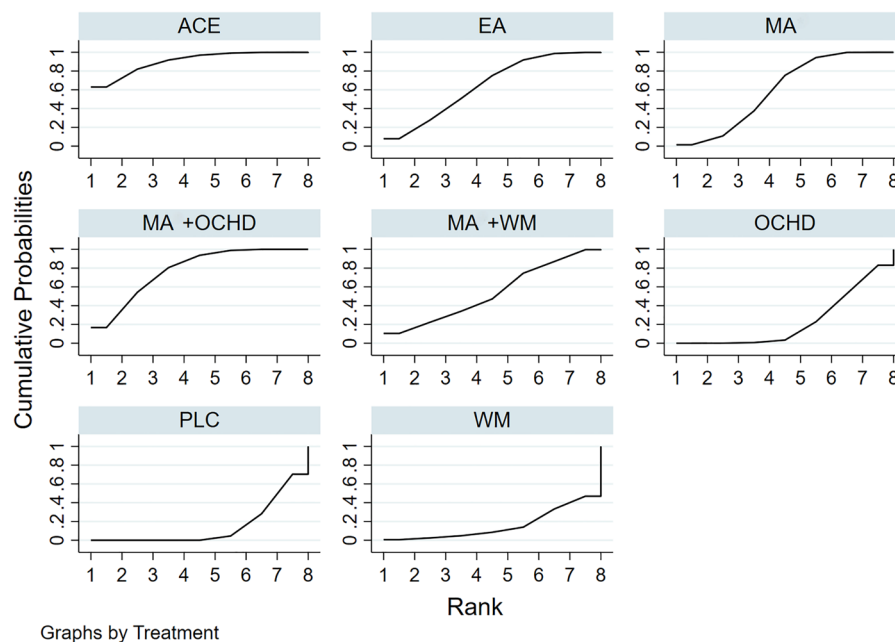


Figure 10. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve L_{Sa}O₂ in SAS patients. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

L_{Sa}O₂ was significantly higher in the AP group than in the routine therapy group [16,19–22]. Another study showed that L_{Sa}O₂ significantly increased in the AP group compared with the nCPAP group [17]. In this NMA, it was found that EA and MA were significantly effective in shortening LAT, MA+OCHD and EA were significantly effective in raising L_{Sa}O₂ in SAS patients.

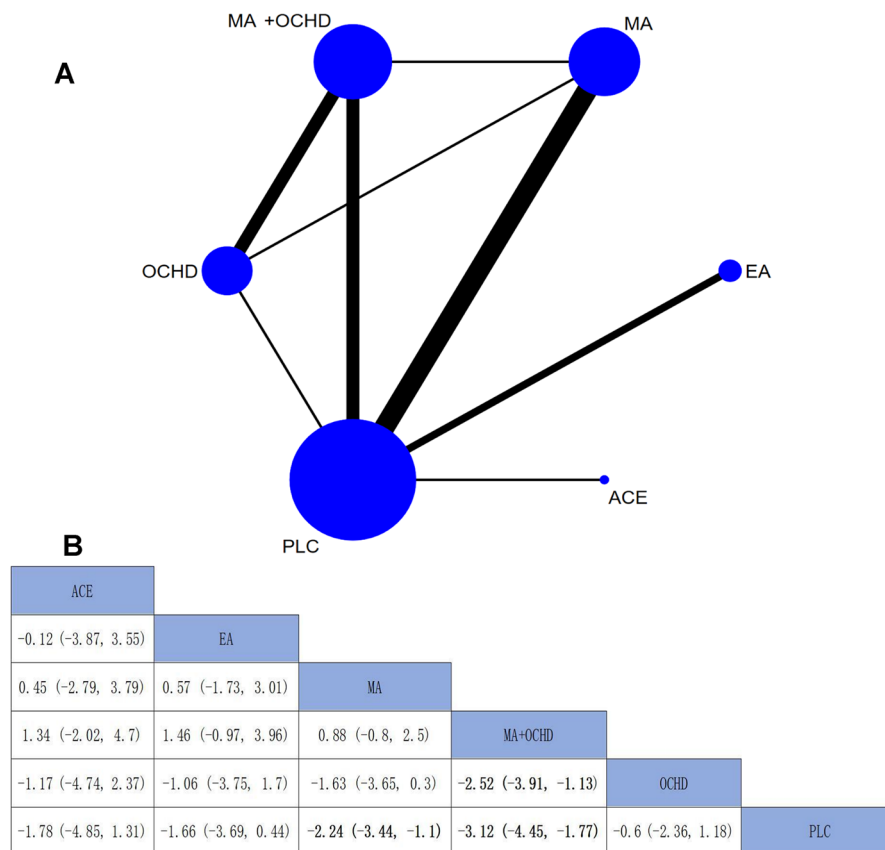


Figure 11. Network diagram and NMA results. (A) Network diagram of ESS (point); (B) Relative impact of different AP therapies on ESS. Estimates are described by MD and 95% CrI (in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; OCHD: oral Chinese herbal decoction; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; WM: Western medicine; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

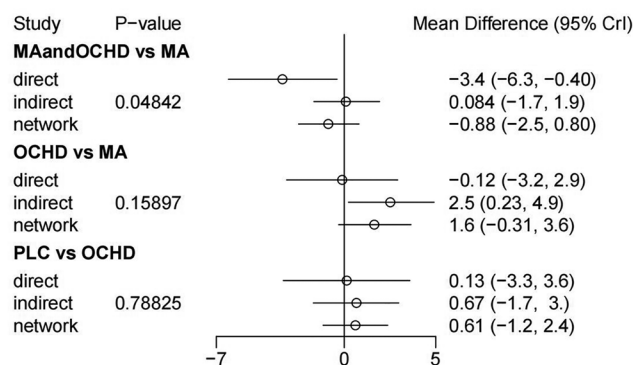


Figure 12. Results of inconsistent tests. Consistency tests were used to assess the internal consistency of the data. Mean difference (MD) and 95% confidence interval (CrI; In parentheses). $p > 0.05$ indicated that there was no inconsistency of outcome, and $p < 0.05$ indicated that there was no regional inconsistency of outcome. MA: manual acupuncture; PLC: placebo; OCHD: oral Chinese herbal decoction; MA and OCHD: manual acupuncture plus oral Chinese herbal decoction.

The other most important factor contributing to SAS is obesity. Obese patients are more prone to upper airway collapse and suffer inflammatory responses such as vascular endothelial damage and oxidative stress, which can further worsen sleep structure disorders. Weight control is considered the main therapeutic option for SAS patients [85]. AP can invigorate the spleen and warm Yang, dispel dampness

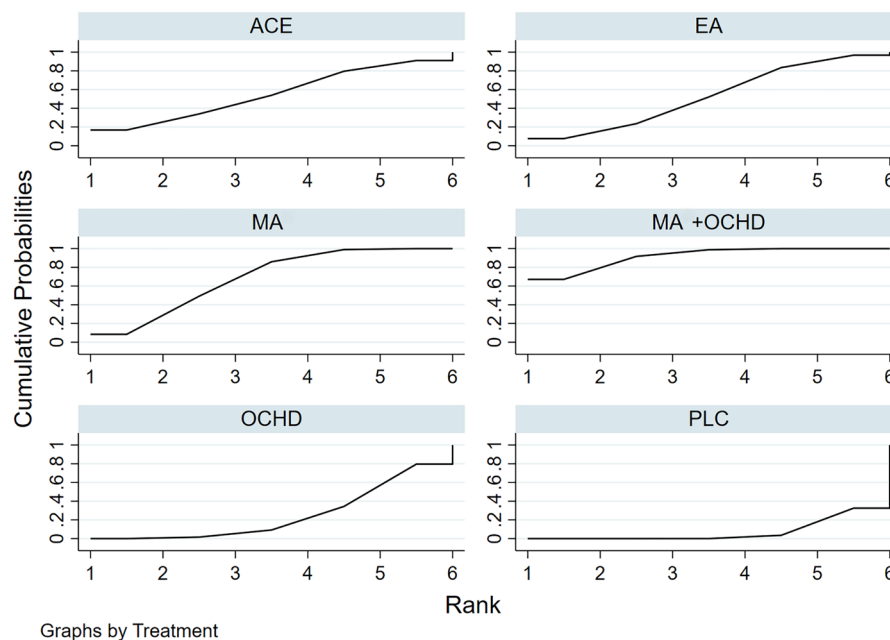


Figure 13. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve ESS in SAS patients. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

and reduce turbidity, dredge the intestine, and help SAS patients return to normal metabolism. A wealth of clinical experience has been accumulated in ACE for weight loss, which is regarded as a 'green' method of weight loss [86,87], and can be used as an adjunctive treatment for SAS plus obesity. By catgut implantation at acupoints using special needles, ACE can produce a more intense AP effect than filiform needle AP [88], achieving a long-lasting effect [89]. ACE has been often applied at Pishu, Sanjiaoshu, Guanyuan, Zhongwan, Shuifen, Fenglong, Daheng, Yinlingquan, Tianshu, and Shuidao acupoints [44,45,90]. With such stimulation usually lasting for 15 d, the deficiencies of routine AP and simple Western medicine are made up for [91], achieving a long-lasting effect [89]. In this NMA, it was found that ACE was the best choice to improve both LAT and LSaO₂ in SAS patients.

Daytime sleepiness is one of the main manifestations of OSAS patients. Sleepiness and somnolence in snoring sufferers had been described in the *Treatise on Febrile Diseases*, a classic ancient Chinese medical book, which is attributed to phlegm-dampness. In modern medicine, the functions of the lungs, spleen, and kidneys are regulated by TCM to support healthy energy, expel phlegm and resolve turbidity while strengthening the spleen and supplementing the lung, thereby significantly ameliorating daytime sleepiness in SAS patients [69,92]. Oral Chinese medicine supplemented with AP at acupoints near the pharynx and brainstem respiratory center in front of and at the back of the neck (Lianquan, Renying, Fengfu, and Yamen), which can not only promote the driving force of respiratory center on the respiratory muscle groups, and restore the pharyngeal dilator muscle, but also relax the tendons and dredge collaterals, restore consciousness, and improve morning drowsiness, lethargy, and headache [43]. Five studies showed significantly lower ESS scores in the AP group than in the routine therapy group [16,19–22], and one study showed significantly lower ESS scores in the AP group than in the nCPAP group [17]. In this NMA, we found that MA+OCHD, MA, and ACE were effective in reducing ESS scores, especially MA+OCHD.

It has been suggested that the loss of circadian rhythm of dip-type blood pressure is associated with SAS and its severity [93–95], and that hypoxemia and hypercapnia caused by apnea can activate nocturnal sympathetic activity of the renin-angiotensin-aldosterone system [96,97], further aggravating the severity of apnea. Moreover, AP also effectively corrects hypoventilation by facilitating local microcirculation and relieving tissue edema [53], and works by regulating the immune stress response and reducing tissue damage [82]. In this NMA, we found that MA+WM, MA+OCHD, and ACE effectively raised the total effective rate, especially MA+WM. Some research suggests that loss of dipper blood pressure circadian

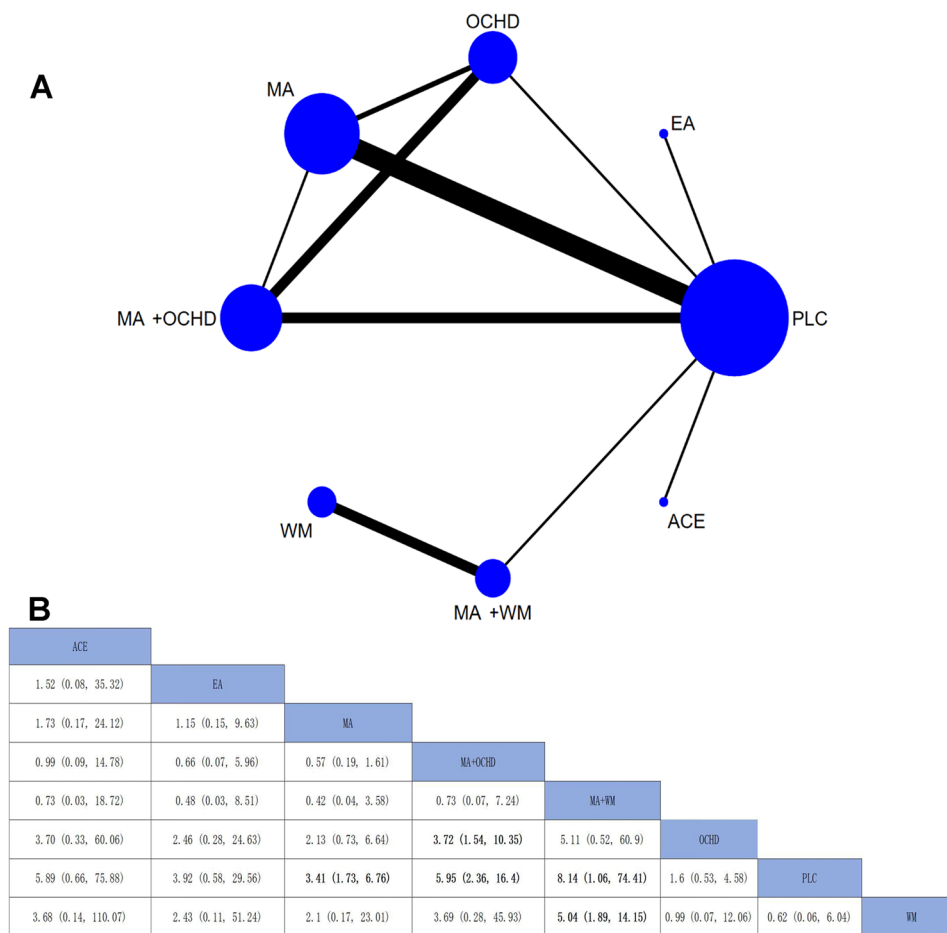


Figure 14. Network diagram and NMA results. (A) Network diagram of total effective rate (%); (B) Relative impact of different AP therapies on total effective rate. Note: Estimates are described by MD and 95% CrI (in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction; MA+WM: manual acupuncture plus Western medicine.

rhythm is correlated with SAS and its severity, and that apnea-induced hypoxemia and hypercapnia can activate the nocturnal sympathetic activity of the renin-angiotensin-aldosterone system, disrupting the normal dipper blood pressure rhythm [93–97]. Therefore, keeping a normal blood pressure circadian rhythm is essential for the effective treatment of SAS. TCM holds that liver qi stagnation and hyperactivity of liver-yang are the major pathogenesis of hypertension in SAS. AP can relieve qi stagnancy in the liver to dissipate sorrow, calm the liver, and suppress yang, thereby effectively controlling and reducing the blood pressure of SAS patients. Based on oral antihypertensive drugs, Huang YH(63) applied AP at Yingxiang, Yintang, and Taixi acupoints. They found that AP improves respiratory disturbance and reduces hypoxemia and hypercapnia by clearing the nasal passage, and restores normal dipper blood pressure rhythm by tonifying kidney-yin and suppressing liver-yang.

AP plus TCM can regulate the function of internal organs, ‘strengthen body resistance and eliminate evil’. In this NMA, MA+OCHD and MA were safer. MA+OCHD is highly acceptable to patients, safe, and effective as compared to nCPAP and surgery. One trial on MA+continuous positive airway pressure reported skin ulceration in five cases (12.50%), which was cured by topical disinfection without infection progression [48]. Another study on MA alone observed hematoma with minor infections in two patients (3.27%) [56], while a separate investigation of MA documented needling syncope in one case (2.38%) [65].

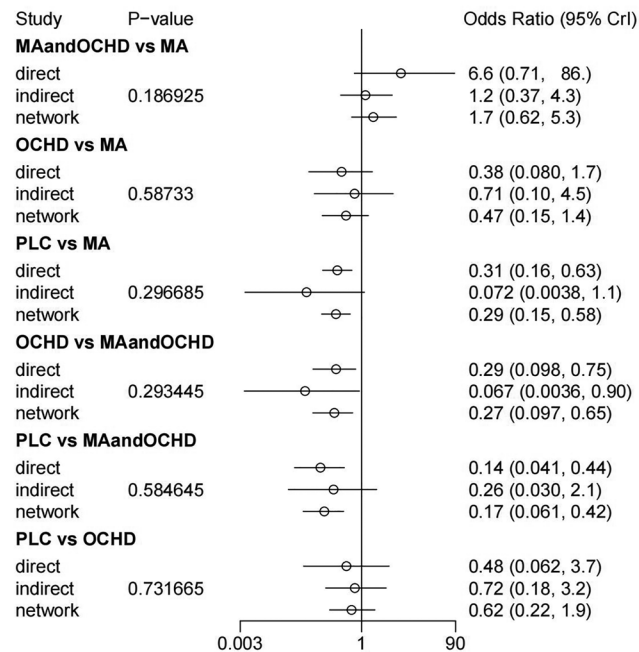


Figure 15. Results of inconsistent tests. Note: Consistency tests were used to assess the internal consistency of the data. Mean difference (MD) and 95% confidence interval (CrI; In parentheses). $p > 0.05$ indicated that there was no inconsistency of outcome, and $p < 0.05$ indicated that there was no regional inconsistency of outcome. MA: manual acupuncture; PLC: placebo; OCHD: oral Chinese herbal decoction; MA and OCHD: manual acupuncture plus oral Chinese herbal decoction.

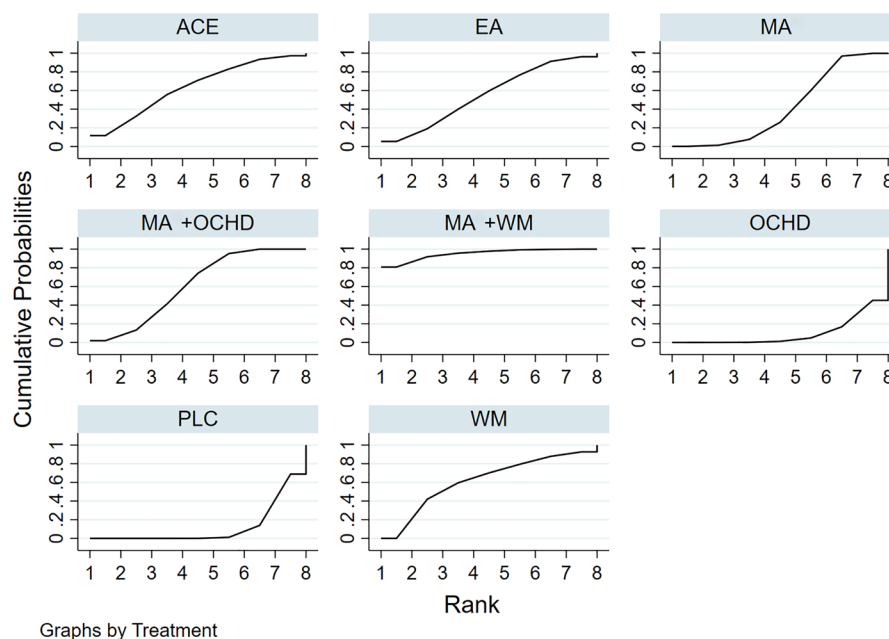


Figure 16. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve Total effective rate in SAS patients. MA: manual acupuncture; EA: electroacupuncture; MA+WM: manual acupuncture plus Western medicine; WM: Western medicine; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

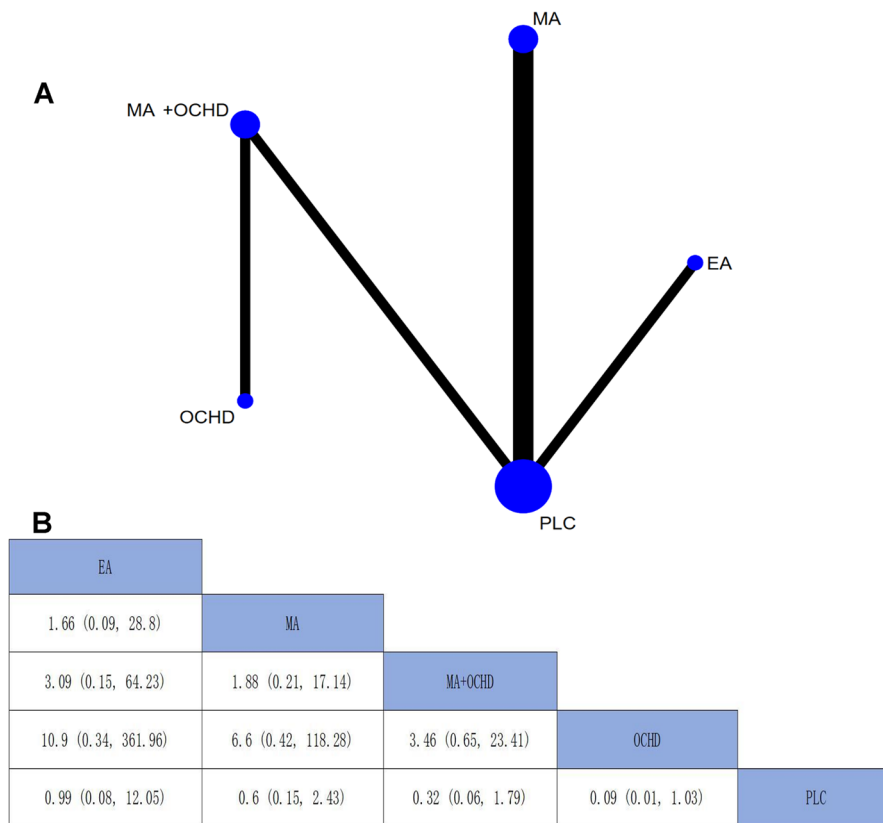


Figure 17. Network diagram and NMA results. (A) Network diagram of incidence of AEs (%); (B) Relative impact of different AP therapies on incidence of AEs. Estimates are described by MD and 95% CrI (in parentheses). Treatment comparisons should be read from right to left. The supplement estimate is located in the cell shared by the column-defining and row-defining treatments. Significant results are bolded. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

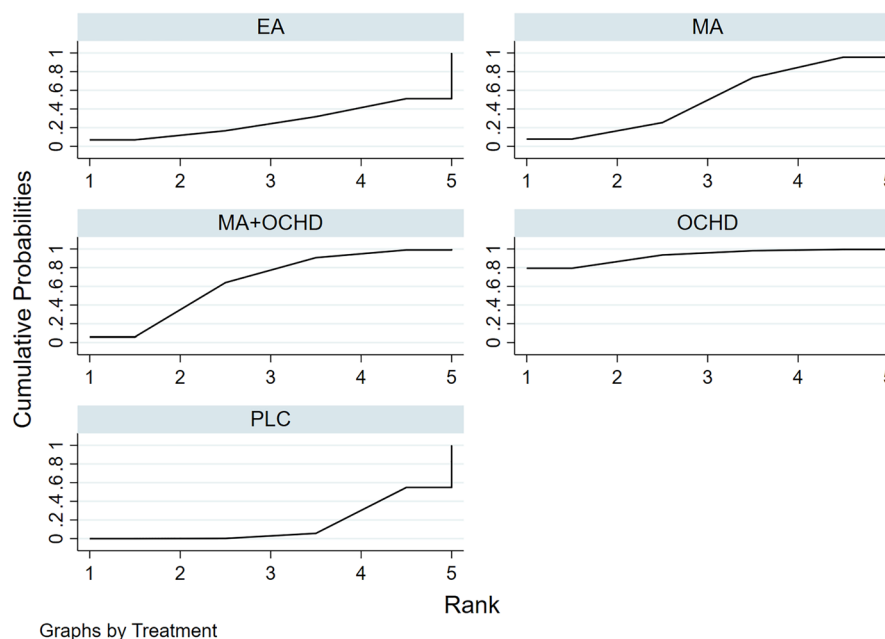


Figure 18. Cumulative probability ranking plot results. The cumulative probability line plot is used to show the distribution of cumulative probability of different acupuncture methods to improve AEs in SAS patients. MA: manual acupuncture; EA: electroacupuncture; PLC: placebo; ACE: acupoint catgut embedding; OCHD: oral Chinese herbal decoction; MA+OCHD: manual acupuncture plus oral Chinese herbal decoction.

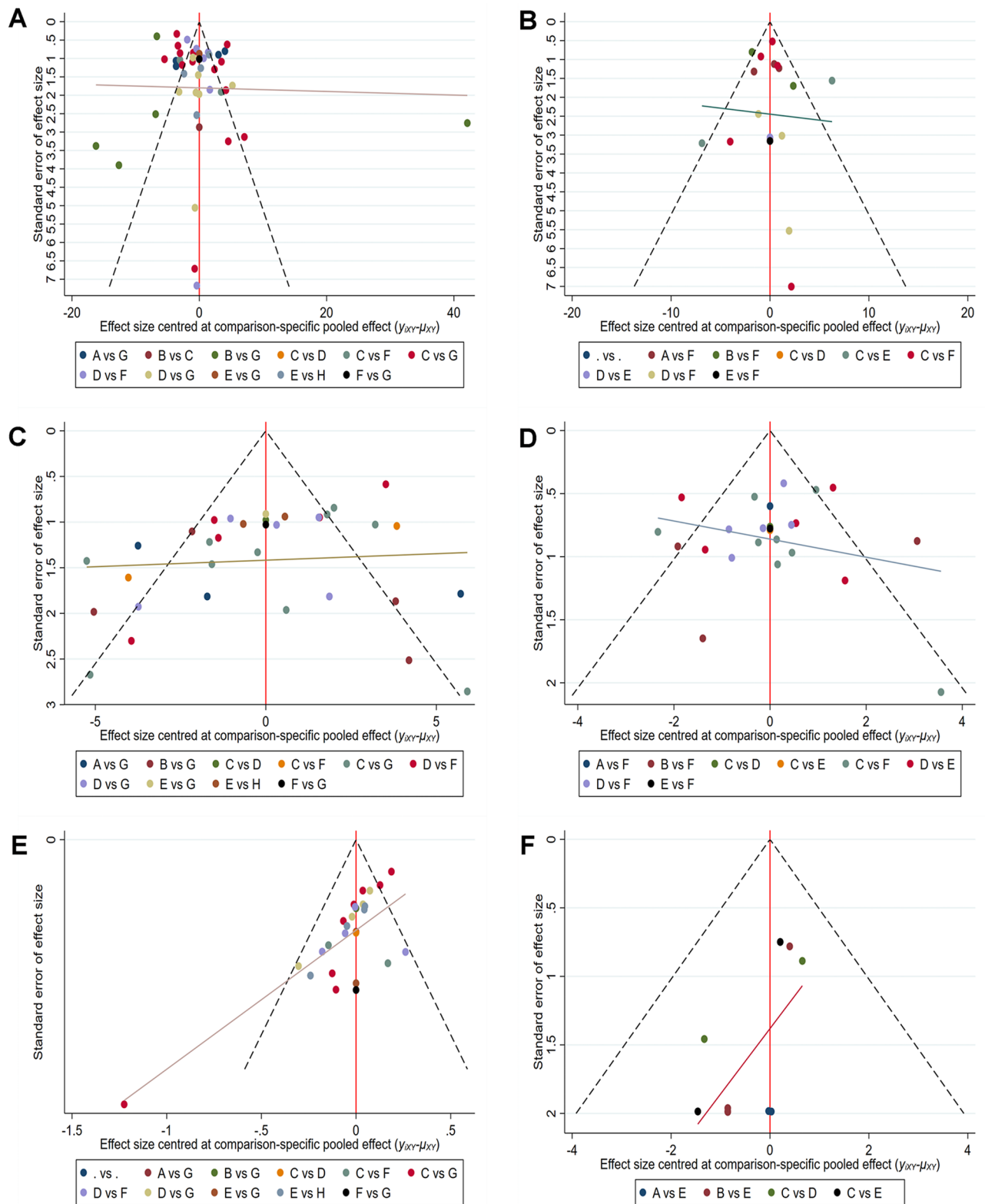


Figure 19. (A) Funnel plot of AHI; (B) Funnel plot of LAT; (C) Funnel plot of LSaO₂; (D) Funnel plot of ESS; (E) Funnel plot of total effective rate, and (F) Funnel plot of Aes.

4.1. Strengths and deficiencies

This is the first NMA comparing the efficacy of different AP therapies on OSAS. NMA not only allows for a comprehensive assessment of the effectiveness of multiple interventions but also provides a ranking of relative effectiveness. However, some deficiencies were still present. Firstly, differences in the disease severity, baseline clinical values, duration of treatment, and selection of acupoints might influence the results. Secondly, the sample size was small in some studies and limited evidence was available for direct comparisons of interventions. Thirdly, most of the included studies had a moderate level of quality, mainly attributed to bias in analytical methods and measurement results, which may restrict the credibility of the evidence as a whole. In addition, randomization bias and missing outcome data may have led to a deviation of the pooled effect size.

5. Conclusion

AP produces a significant effect in treating SAS. Specifically, EA is effective in reducing AHI, ACE is effective in reducing LAT and increasing LSaO₂, MA+OCHD can improve sleepiness, MA+WM achieves the highest total effective rate, and OCHD has the best safety profile. These results should be interpreted with caution, and more large-sample high-quality RCTs are required in the future.

Acknowledgments

All authors contributed to the study conception and design. Writing - original draft preparation: YL, LG, WC, BZ, XG; Writing - review and editing: YL; Conceptualization: YL; Methodology: YL; Formal analysis and investigation: LG, WC, BZ; Funding acquisition: XG; Resources: XG; Supervision: XG, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Author contributions

CRedit: **Yun Li**: Conceptualization, Methodology, Writing – original draft, Writing – review & editing; **Ling Gao**: Formal analysis, Investigation, Writing – original draft; **Xiyan Gao**: Funding acquisition, Resources, Supervision, Writing – original draft; **Wenming Chu**: Formal analysis, Investigation, Writing – original draft; **Boyu Zhang**: Formal analysis, Investigation, Writing – original draft.

Disclosure statement

The Authors declares that there is no conflict of interest.

Funding

The study was supported by Project funded by the National Natural Science Foundation of China: Exploring the mechanism of acupuncture at Points in Heel Vessel on improving the damage to the gabaergic signaling system in insomnia rats based on the theoretical foundation of IL-1 β regulating the PI3K/AKT signaling pathway (82474655).

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Data availability statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

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