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ORIGINAL RESEARCH

Comparative Efficacy of Various Acupuncture-Related Therapies for Post-Stroke Sleep Disorders: A Network Meta-Analysis of Randomized Controlled Trials

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Background: Post-stroke sleep disorders (PSSD) are among the most prevalent complications of stroke, significantly impeding neurological recovery and increasing the risk of recurrence. While Western medicine primarily relies on pharmacological treatments, these often come with side effects and inconsistent outcomes. Recent evidence supports the effectiveness of various acupuncture therapies for PSSD, but the optimal treatment strategy remains unclear.

Objective: To compare the efficacy of different acupuncture therapies for PSSD using a network meta-analysis.

Methods: We conducted systematic searches in multiple databases, including CNKI (since 1994), VIP (since 1989), CBM (since 1978), WanFang (since 1998), the Chinese Clinical Trial Registry (since 2005), PubMed (since 1966), EMBASE (since 1974), The Cochrane Library (since 1993), Web of Science (since 1900), and ClinicalTrials (since 2000). Randomized controlled trials (RCTs) on acupuncture therapies for PSSD were included up to May 31, 2024. Studies were screened based on predefined inclusion and exclusion criteria, and their quality was assessed using the Cochrane Handbook for Systematic Reviews of Interventions. Data were analyzed using RevMan 5.3 and Stata 14.

Results: A total of 53 RCTs involving 3973 patients were included. The network meta-analysis evaluated 12 interventions. Auricular acupressure combined with Western medicine ranked highest for improving PSQI scores (surface under the cumulative ranking curve [SUCRA]: 96.2%), followed by acupuncture (68.5%) and moxibustion combined with Western medicine (63.6%). For increasing serum 5-HT levels, moxibustion combined with Western medicine ranked highest (SUCRA: 89.3%), followed by acupuncture combined with Western medicine (79.1%). Acupuncture combined with Western medicine was most effective in reducing serum NE levels (SUCRA: 97%).

Conclusion: Acupuncture therapies are effective for PSSD and it is more effective when used in combination with western medicine. These effects may be mediated by modulating neurotransmitter levels. However, further large-scale, multi-center RCTs are needed to confirm these findings. This study followed PRISMA guidelines and was registered with PROSPERO (CRD42023470398).

Keywords: acupuncture and moxibustion therapy, stroke, sleep disorders, network meta-analysis, PSQI, 5-HT, NE

Introduction

Post-stroke sleep disorders (PSSD) are a group of clinical syndromes characterized by the onset of sleep disturbances following a stroke or the persistence and exacerbation of pre-existing sleep disorders after a stroke, meeting the diagnostic criteria for sleep disorders.[1] PSSD is a common complication after a stroke.[2] PSSD arise from a complex interplay of neurological, biochemical, and psychological mechanisms. Damage to key brain regions, such as the thalamus, hypothalamus, and brainstem, caused by stroke, disrupts the regulation of the sleep-wake cycle.[3] These areas are crucial for maintaining circadian rhythms and modulating neurotransmitters involved in sleep regulation, including serotonin (5-HT), norepinephrine (NE), and gamma-aminobutyric acid (GABA).[4] Moreover, stroke-induced

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inflammation and oxidative stress disturb the balance between pro-inflammatory and anti-inflammatory cytokines, such as interleukin-6 (IL-6) and tumor necrosis factor-alpha (TNF-α).[5,6] Additionally, psychological factors, including post-stroke depression and anxiety, significantly contribute to the development and persistence of PSSD.

Sleep disturbances can induce inflammatory responses, worsen depression and anxiety, and further impair vascular reactivity, which not only severely hinders neurological recovery but also increases the risk of stroke recurrence.[7] Current Western medical treatments primarily rely on pharmacotherapy, including benzodiazepines, non-benzodiazepines, melatonin receptor agonists, antidepressants, and orexin receptor antagonists.[8] However, these medications often carry risks such as side effects, addiction, drug resistance, and inconsistent efficacy with long-term use. Consequently, acupuncture therapy has gained increasing attention for managing PSSD.

Acupuncture alleviates PSSD through several distinct mechanisms.[9] First, it modulates cerebral hemodynamics by improving blood flow to ischemic brain regions, facilitating the restoration of normal function in sleep-regulating brain areas.[10] Second, acupuncture regulates key neurotransmitters involved in sleep regulation, with studies demonstrating increased expression of serotonin (5-HT) and gamma-aminobutyric acid (GABA) alongside reduced levels of norepinephrine (NE).[11] Third, acupuncture exhibits anti-inflammatory and antioxidant properties by downregulating pro-inflammatory cytokines and enhancing antioxidant enzyme activity, thereby reducing neuroinflammation and oxidative stress.[12] Furthermore, acupuncture stimulates specific acupoints to activate the vagus nerve, which modulates neuroendocrine functions and promotes the restoration of normal sleep patterns.

Acupuncture therapies include various modalities such as acupuncture, moxibustion, auricular acupressure, and acupoint sticking therapy, each exhibiting distinct therapeutic effects. However, direct comparative studies among these different acupuncture methods remain lacking. Network meta-analysis can synthesize evidence from multiple interventions for the same condition and provide indirect comparisons, enabling ranking and identification of the optimal approach.[13] This study employs network meta-analysis to evaluate the efficacy of different acupuncture therapies for post-stroke sleep disorders, offering evidence-based recommendations for clinical practice.

Materials and Methods

Study Registration

This study was registered with PROSPERO (registration number: CRD42023470398). No conflicts of interest were reported.

Literature Search

Systematic searches were performed across multiple databases, including CNKI (since 1994), VIP (since 1989), CBM (since 1978), WanFang (since 1998), the Chinese Clinical Trial Registry (since 2005), PubMed (since 1966), EMBASE (since 1974), The Cochrane Library (since 1993), Web of Science (since 1900), and ClinicalTrials.gov (since 2000). The search encompassed all studies published from the inception of each database until May 31, 2024. In accordance with the PICOS framework, a comprehensive search strategy was developed using a combination of controlled vocabulary and free-text terms. The Chinese search terms included "zhen", "zhenjiu", "zhenci", and "jiu", while the English search terms included "acupuncture" and "acupuncture therapy." The detailed retrieval strategies for each database are provided in Tables S1 and S2.

Eligibility Criteria

Inclusion Criteria

The study was conducted according to the PICOS framework.

P (Population)

Patients with a definitive diagnosis of PSSD were included. The diagnosis of PSSD was based on the International Classification of Sleep Disorders (ICSD-3),[14] Chinese guidelines for diagnosis and treatment of acute ischemic stroke 2018,[15] Chinese guidelines for diagnosis and treatment of acute intracerebral haemorrhage 2019,[16] which include:

A history of stroke confirmed by imaging (eg, CT or MRI).

The presence of sleep disturbances that meet the diagnostic criteria for sleep disorders according to ICSD-3.

Sleep disturbances that either developed after the stroke or were exacerbated by the stroke.

I (Interventions)

Patients received either a single acupuncture therapy or a combination of acupuncture and Western medication. Acupuncture therapies included standard acupuncture, electroacupuncture, auricular acupressure, thunder-fire moxibustion, moxibustion, and intradermal needle. Detailed descriptions of each intervention are provided in Table 1.

C (Comparison)

Patients were treated with Western medicine.

Both groups received consistent basic care.

Definition of Western Medicine

In this study, "Western medicine" refers to conventional medical practices based on scientific evidence, including pharmacological treatments such as hypnotic drugs, antidepressants, and other standardized therapies.

O (Outcome)

Primary Outcome. Pittsburgh Sleep Quality Index (PSQI),[17] which consists of 18 items and 7 components, with a total score of 21 points (higher scores indicate poorer sleep quality).

Secondary Outcomes. Serum levels of 5-HT[18] and NE.[19]

S (Study Design)

Randomized controlled trials (RCTs) with a control group and an intervention group were included. Studies published in English or Chinese were considered.

Table 1 Introduction to Different Interventions

Interventions	Description
Western medicine	Conventional medical practices based on scientific evidence, including pharmacological treatments such as hypnotic drugs, antidepressants, and other standardized therapies.
Acupuncture	Acupuncture refers to the practice of inserting needles (usually filiform needles) into a patient's body at a certain angle under the guidance of traditional Chinese medicine theory, using techniques such as twisting and lifting to stimulate specific parts of the body and achieve the goal of treating diseases
Electroacupuncture	It is a method of preventing and treating disease by combining needle and electrical stimulation by passing a trace current close to the body's bioelectricity through the needle tool after the needle has been inserted into the acupoint to obtain Qi.
Ear acupressure beans	Ear acupressure is a health care method developed on the basis of ear acupuncture therapy. The specific operation is to apply smooth and nearly spherical or oval shaped traditional Chinese medicine seeds such as Wangbuliuxing seeds or small mung beans to the center of a small piece of adhesive tape measuring 0.6×0.6 cm, then align it with the ear points and apply a little pressure to make the patient's ears feel sore, numb, swollen or warm.
Thunder fire moxibustion	Thunder fire moxibustion is a widely used traditional Chinese medicine therapy, which is made from various traditional Chinese medicines and uses the principle of meridian theory to treat human diseases with functions such as supporting the body and eliminating evil.
Moxibustion	It is a treatment method that uses moxa leaves to make moxa sticks, moxa pillars, which produce moxa heat to stimulate acupuncture points or specific areas of the body for the purpose of preventing and treating disease
Di acupuncture needle	It is also known as the non-insertion acupuncture needle or press needle, is a unique tool in traditional Chinese medicine (TCM) acupuncture. Unlike conventional acupuncture needles that penetrate the skin, the Di needle is designed for superficial stimulation of acupoints. It is typically used to apply gentle pressure or massage on specific points along the body's meridians, making it a non-invasive and painless therapeutic option.
Intradermal needle	Intradermal needle (subcutaneous buried needle) is a type of acupuncture method. The method involves using disinfected short needles or press needles, typically 0.5 to 1 inch (1.27 to 2.54 cm) in length. After oblique puncture (transverse puncture) is inserted subcutaneously (with the needle handle exposed), it is fixed with adhesive tape and left under the skin for one to seven days, provided there is no local pain and no impact on the patient's limb movement. This technique is performed under strict aseptic conditions and is monitored closely to ensure patient safety.

Exclusion Criteria

Participants in the acute phase of stroke (within 2 weeks of stroke onset).

Patients with other sleep disorders not related to stroke (eg, obstructive sleep apnea, restless legs syndrome, narcolepsy).

Full-text information, intervention methods, or outcome measures that do not meet the inclusion criteria.

Duplicate publications (only the most recent version or those with accurate data were included).

Studies with unclear or undefined study designs.

Conference papers, theses, and non-peer-reviewed articles.

Selection Process

The Note Express 3.0 reference management system was employed to organize the literature, identify duplicates, and eliminate redundant records. Two researchers independently screened the titles and abstracts to preliminarily exclude ineligible studies, followed by a full-text review to confirm the final selection. The researchers then compared their selections, and any disagreements were resolved through discussion or, if necessary, consultation with a third party.

Data Extraction and Analysis

Two researchers independently extracted data using a custom-designed data extraction form, followed by cross-checking for accuracy. Discrepancies were resolved as previously outlined. Extracted data included: (1) basic study information, such as title, first author, and publication year; (2) key characteristics of study participants, interventions, and outcomes; (3) critical elements for assessing risk of bias; and (4) outcome measures of interest. The literature quality assessment was conducted using Review Manager 5.3, and network meta-analysis and plotting were performed with Stata 14.1. In this study, all outcome data are continuous variables, with mean difference (MD) or standardized mean difference (SMD) serving as effect size indicators, alongside a 95% confidence interval (CI) for the pooled effect size. Consistency was evaluated through the inconsistency model, the node-splitting method, and closed-loop consistency assessment. When closed loops were identified, loop inconsistency tests were applied. Treatment effects were ranked using the surface under the cumulative ranking curve (SUCRA), where values closer to 100% indicate higher efficacy of the intervention. For outcome indicators with more than 10 studies, a funnel plot was used to evaluate publication bias.

Risk of Bias Assessment

The risk of bias was assessed using the Cochrane Risk of Bias Tool. Two independent reviewers evaluated each study, and discrepancies were resolved through discussion or consultation with a third reviewer.

Results

Literature Search Results

A total of 1871 relevant studies were retrieved, comprising 1737 Chinese studies and 134 English studies. The sources included CNKI (n=335), VIP (n=258), WangFang Data (n=627), CBM (n=517), ChiCTR (n=0), PubMed (n=20), EMBASE (n=49), The Cochrane Library (n=32), WOS (n=33), and ClinicalTrials (n=0). After screening, 53 studies were ultimately included, all of which were in Chinese.[20–72] The literature screening process and results are shown in Figure 1.

Study Characteristics

A total of 53 studies, all randomized controlled trials (RCTs), were included, involving 3973 participants, with 2001 in the experimental group and 1972 in the control group. Baseline characteristics were comparable across all studies. Table S3 provides basic information on the included studies.

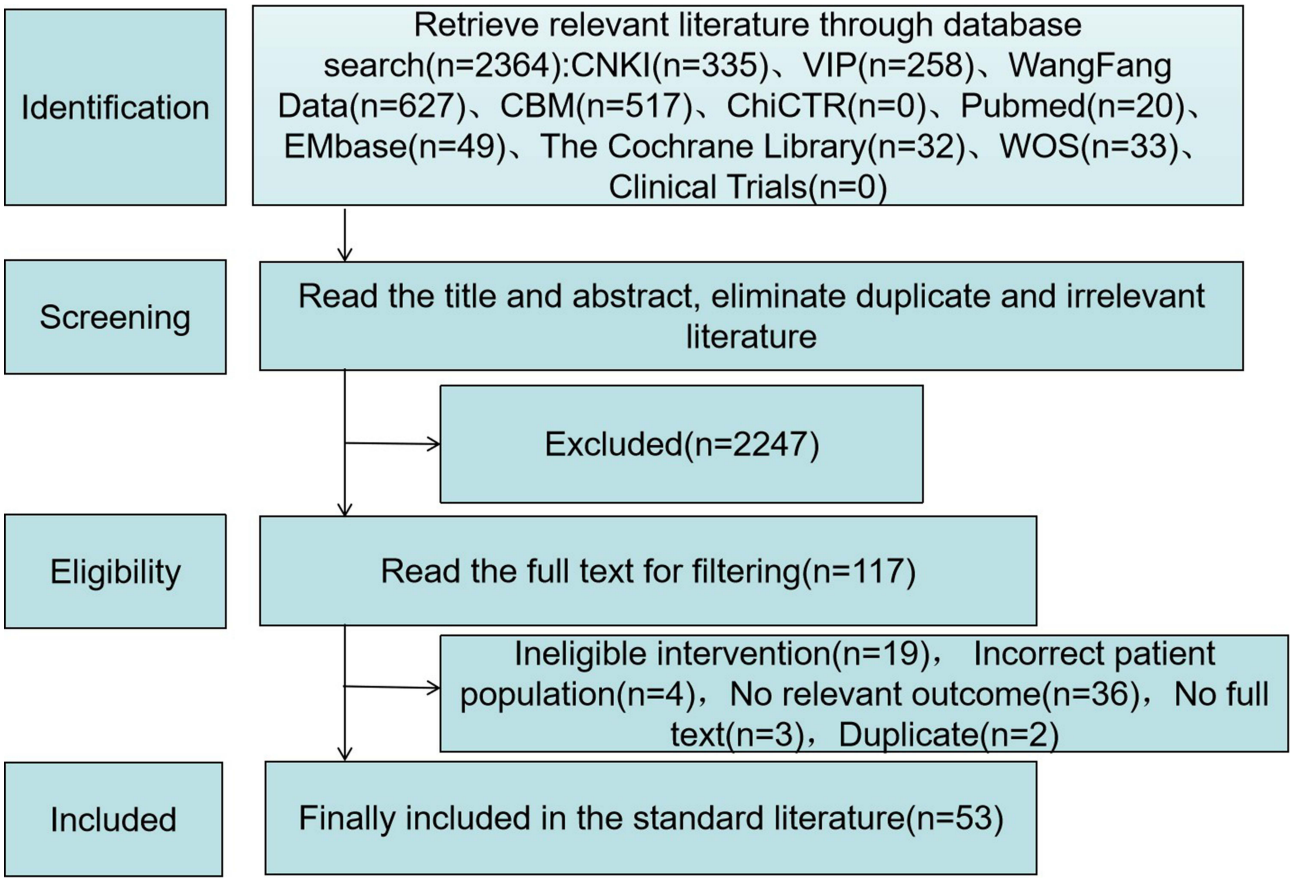

Figure 1 Literature search process.

Risk Bias Assessment

Random Sequence Generation: A total of 31 studies[21,24–42,44,50,51,54,56,58,61,64–66,68] used a random number table method, 2 studies[23,49] employed random sampling, and 1 study[57] utilized block randomization, all of which were assessed as having a low risk of bias. Four studies[43,48,59,70] allocated participants based on the order of visits, which was classified as high risk. Fifteen studies[20,22,45–47,52,53,55,60,62,63,67,69,71,72] mentioned the use of "random" without specifying the method, resulting in an assessment of "uncertain risk."Allocation Concealment: None of the studies described the methods used for allocation concealment, leading to an "uncertain risk" assessment. Blinding: One study[69] employed single blinding, and one study[20] used double blinding; both were assessed as low risk. The remaining studies did not report any blinding, resulting in an "uncertain risk"assessment. Completeness: Nine studies[22,24,25,27,31,33,36,40,52] reported participant dropout with clear explanations and a minimal number of cases, which were classified as low risk. Selective Reporting: No evidence of selective reporting was identified in any study, resulting in a "low risk" assessment. Other Biases: No additional biases were reported in any study, leading to a "low risk" assessment. The risk of bias assessment for the included studies is shown in Figures 2 and S1.

Network Meta-Analysis

Network Meta-Analysis of PSQI Scores

A total of fifty RCTs[20–46,48–57,59–65,67–72] reported on the PSQI scores of patients with PSSD treated through acupuncture therapies. Twelve intervention types were included: Western medicine, acupuncture, electroacupuncture, auricular acupressure, thunder-fire moxibustion, moxibustion, Di acupuncture needle, intradermal needling, acupuncture combined with Western medicine, moxibustion combined with Western medicine, Acupoint sticking therapy combined with Western medicine, and auricular acupressure combined with Western medicine, forming a triangular closed loop. The

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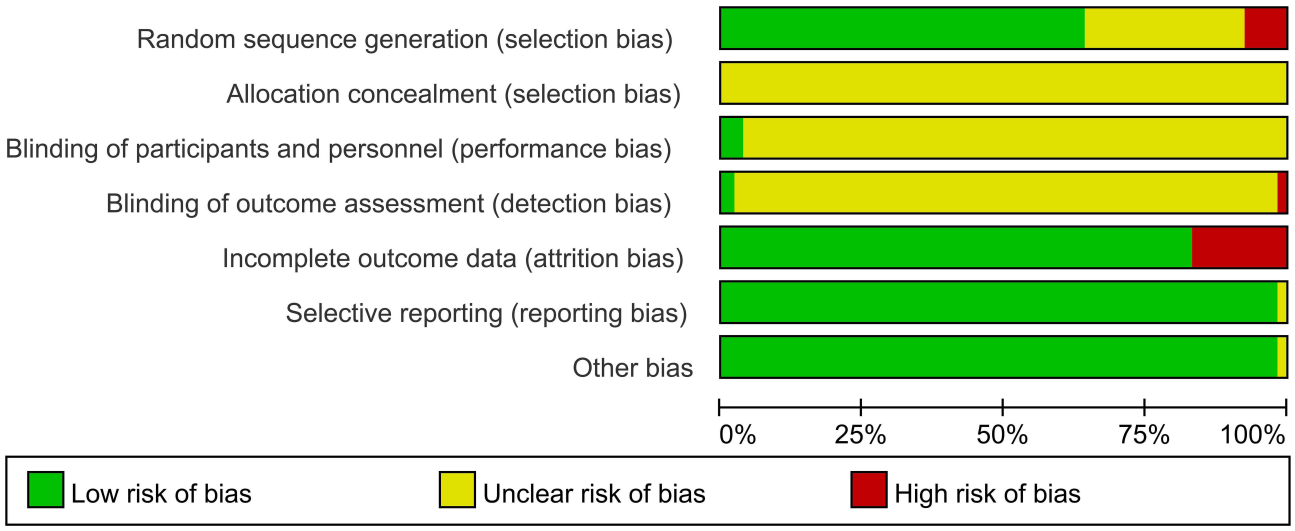

Figure 2 Literature bias evaluation results.

network of relationships among interventions is illustrated in Figure 3, where node size indicates the number of original studies, and line thickness represents the frequency of direct comparisons. Pairwise comparisons of interventions showed that auricular acupressure combined with Western medicine, acupuncture, moxibustion combined with Western medicine, auricular acupressure, and acupuncture combined with Western medicine significantly improved PSQI scores in patients with PSSD compared to controls ($P < 0.05$), as presented in Table 2. The SUCRA for improvement in PSQI scores across the 12 acupuncture therapies ranked as follows: auricular acupressure combined with Western medicine (96.2%) > acupuncture (68.5%) > auricular acupressure (64%) > moxibustion combined with Western medicine (63.6%) > thunder-fire moxibustion (62.8%) > moxibustion (57.5%) > acupuncture combined with Western medicine (53.8%) > needle-embedding therapy (47.1%) > Acupoint sticking therapy combined with Western medicine (39.8%) > intradermal needling (26.6%) > electroacupuncture (10.9%) > Western medicine (9.1%), as shown in Figure S2. The funnel plot demonstrated poor symmetry, with most studies falling outside the inverted triangle, indicating potential publication bias or small-sample effects for this outcome, as shown in Figure S3.

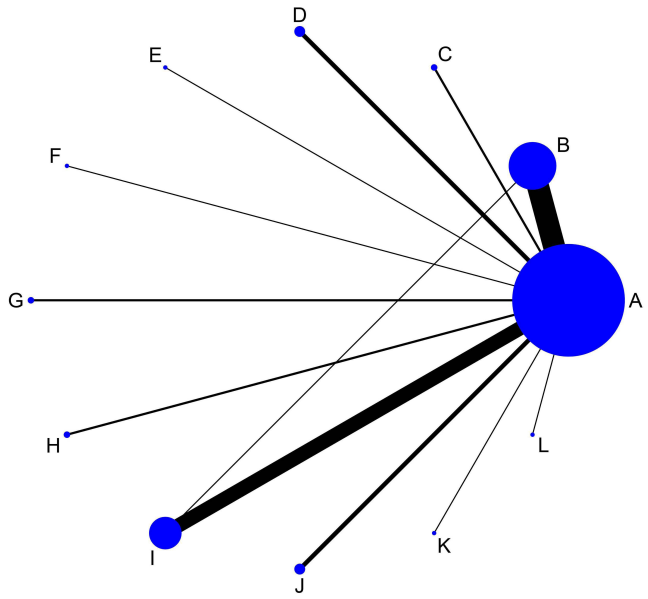

Figure 3 Network diagram of the PSQI.
Notes: (**A**) Western medicine (**B**) Acupuncture (**C**) Electroacupuncture (**D**) Auricular acupressure (**E**) Thunder-fire moxibustion (**F**) Moxibustion (**G**) Di acupuncture needle (**H**) Intradermal needle (**I**) Acupuncture+Western medicine (**J**) Moxibustion+Western medicine (**K**) Acupoint sticking therapy+Western medicine (**L**) Auricular acupressure+Western medicine.

Table 2 Network Meta-Analysis of PSQI [MD (95% CI)]

Treatment	Auricular Acupressure +Western Medicine	Acupuncture	Moxibustion +Western Medicine	Auricular Acupressure	Thunder-Fire Moxibustion	Moxibustion	Acupuncture +Western Medicine	Di Acupuncture Needle	Acupoint Sticking Therapy +Western Medicine	Intradermal Needle	Electroacupuncture	Western Medicine
Auricular acupressure +Western medicine	0											
Acupuncture	−2.84 (−6.01, 0.32)	0										
Moxibustion+Western medicine	−2.99 (−6.45, 0.47)	−0.15 (−1.88, 1.59)	0									
Auricular acupressure	−2.96 (−6.42, 0.50)	−0.12 (−1.86, 1.63)	0.03 (−2.21, 2.27)	0								
Thunder-fire moxibustion	−2.89 (−7.37, 1.59)	−0.05 (−3.38, 3.29)	0.10 (−3.52, 3.72)	0.07 (−3.55, 3.69)	0							
Moxibustion	−3.20 (−7.61, 1.21)	−0.36 (−3.59, 2.88)	−0.21 (−3.74, 3.32)	−0.24 (−3.77, 3.29)	−0.31 (−4.84, 4.22)	0						
Acupuncture+Western medicine	−3.34 (−6.53, −0.14)	−0.49 (−1.59, 0.60)	−0.35 (−2.14, 1.44)	−0.38 (−2.18, 1.42)	−0.45 (−3.82, 2.92)	−0.14 (−3.40, 3.13)	0					
Di acupuncture needle	−3.73 (−7.51, 0.05)	−0.88 (−3.19, 1.43)	−0.74 (−3.44, 1.96)	−0.77 (−3.47, 1.94)	−0.84 (−4.77, 3.09)	−0.53 (−4.37, 3.31)	−0.39 (−2.74, 1.97)	0				
Acupoint sticking therapy +Western medicine	−4.15 (−8.74, 0.44)	−1.31 (−4.78, 2.17)	−1.16 (−4.91, 2.59)	−1.19 (−4.94, 2.56)	−1.26 (−5.97, 3.45)	−0.95 (−5.59, 3.69)	−0.81 (−4.32, 2.69)	−0.42 (−4.47, 3.62)	0			
Intradermal needle	−4.90 (−8.88, −0.92)	−2.06 (−4.67, 0.56)	−1.91 (−4.88, 1.06)	−1.94 (−4.92, 1.04)	−2.01 (−6.13, 2.11)	−1.70 (−5.74, 2.34)	−1.56 (−4.22, 1.10)	−1.17 (−4.51, 2.17)	−0.75 (−4.98, 3.48)	0		
Electroacupuncture	−5.95 (−9.68, −2.21)	−3.10 (−5.33, −0.87)	−2.96 (−5.59, −0.32)	−2.99 (−5.63, −0.35)	−3.06 (−6.94, 0.82)	−2.75 (−6.54, 1.05)	−2.61 (−4.89, −0.33)	−2.22 (−5.27, 0.82)	−1.80 (−5.80, 2.20)	−1.05 (−4.34, 2.24)	0	
Western medicine	−5.92 (−9.00, −2.84)	−3.08 (−3.79, −2.36)	−2.93 (−4.51, −1.35)	−2.96 (−4.55, −1.37)	−3.03 (−6.29, 0.23)	−2.72 (−5.87, 0.43)	−2.58 (−3.44, −1.73)	−2.19 (−4.39, 0.00)	−1.77 (−5.17, 1.63)	−1.02 (−3.54, 1.50)	0.03 (−2.08, 2.14)	0

Abbreviations: MD, mean difference; SMD, standardized mean difference.

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Network Meta-Analysis of Serum 5-HT Levels

A total of 12 RCTs[20,29,31–33,39,44,47,48,50,58,64] investigated serum 5-HT levels in PSSD who were treated with acupuncture therapy. These studies included six intervention measures: moxibustion combined with Western medicine, acupuncture combined with Western medicine, thunder-fire moxibustion, acupuncture, electroacupuncture, and Western medicine. The network relationships among these interventions are illustrated in Figure S4. Pairwise comparisons demonstrated that moxibustion combined with Western medicine, acupuncture combined with Western medicine, fire needle therapy, and acupuncture significantly improved serum serotonin (5-HT) levels in patients with PSSD compared to the control group, with statistically significant differences ($P < 0.05$), as detailed in Table S4. Given the absence of a closed loop among the interventions, consistency testing is not necessary. The cumulative ranking probability plot for the six acupuncture therapies, indicated by the SUCRA, showed the following rankings for improving serum 5-HT levels in PSSD: moxibustion combined with Western medicine (89.3%) > acupuncture combined with Western medicine (79.1%) > fire needle therapy (58.9%) > acupuncture (47.5%) > electroacupuncture (14.5%) > Western medicine (10.7%), as shown in Figure S5. The Funnel plot of 5-HT was presented in Figure S6.

Network Meta-Analysis of Serum NE Levels

A total of five RCTs[32,48,50,58,64] investigated serum norepinephrine (NE) levels in patients with sleep disorders following stroke who received acupuncture therapy. The interventions included four measures: Western medicine, electroacupuncture, acupuncture, and acupuncture combined with Western medicine. The network relationships among these interventions are illustrated in Figure S7. Pairwise comparisons revealed that acupuncture combined with Western medicine significantly reduced serum NE levels in patients with PSSD compared to electroacupuncture and Western medicine, with statistically significant differences ($P < 0.05$), as shown in Table S5. Given the absence of a closed loop among the interventions, consistency testing is not necessary. The cumulative ranking probability plot for the four acupuncture therapies, indicated by the SUCRA, demonstrated the following rankings for reducing serum NE levels in patients with sleep disorders after stroke: acupuncture combined with Western medicine (97%) > acupuncture (39%) > Western medicine (33%) > electroacupuncture (30.3%), as shown in Figure S8.

Discussion

Auricular Acupressure Combined with Western Medicine

The results of this study indicate that acupuncture therapy, whether administered alone or in combination with Western medicine, is more effective than Western medicine alone in improving the PSQI in patients with PSSD, and auricular acupressure combined with Western medicine may be the most effective intervention. This finding is consistent with previous studies,[73] which have also reported the benefits of combining acupuncture-related therapies with Western medicine for sleep disorders.

In traditional Chinese medicine, PSSD are classified under the categories of "stroke" and "insomnia." Factors such as internal injuries, fatigue, emotional disturbances, and dietary influences can generate wind, fire, phlegm, and blood stasis, leading to disturbances in the qi and blood of the organs, which can result in a stroke. This stroke further disrupts the balance of yin and yang, causes organ dysfunction, and disturbs the internal qi, ultimately contributing to the emergence of sleep disorders.[74] Acupuncture therapy stimulates specific acupoints, promotes meridian flow, and activates bodily functions, thereby replenishing the qi and blood of the organs and achieving calming effects to aid sleep.[75] The auricle possesses a rich supply of nerves and blood vessels that connect to the brain. According to the theory of biological holography, the ear region corresponds to the functions of specific organs in the body; stimulating the relevant acupoints can activate the vagus nerve, which regulates neuroendocrine functions and restores normal sleep structure.[76] Furthermore, the bioelectrical theory[77] suggests that the injury current and potential difference generated by pressing ear acupoints can transmit along the meridian electrical axis to affected organs and tissues, thereby exerting therapeutic effects.

Moxibustion Combined with Western Medicine

Our results indicate that moxibustion combined with Western medicine may be the most effective treatment for increasing serum 5-HT levels in patients with PSSD. This is supported by both traditional Chinese medicine theory

and modern research,[78,79] which suggest that moxibustion can enhance local blood circulation and modulate neurotransmitter levels. Animal experiments[80] have demonstrated that moxibustion increases 5-HT levels in the hypothalamus of rat models. Previous studies[81] have shown that the combination of Qi inducing and Yuan regulating acupuncture with Yongquan acupoint moxibustion can upregulate 5-HT levels and improve sleep quality.

Modern research suggests that neurons in areas such as the frontal lobe, temporal lobe, and basal ganglia sustain varying degrees of damage after a stroke, resulting in decreased levels of neurotransmitters, including 5-HT, which diminishes their regulatory effect on sleep, thereby disrupting circadian rhythms and leading to sleep disorders.[82] Moxibustion has a history of thousands of years in China, and its effectiveness in treating post-stroke insomnia has been corroborated by numerous clinical practices. Contemporary medical perspectives suggest that moxibustion can enhance local blood circulation, improve metabolism, and nourish vascular nerves, thus modulating nervous system function.[79] Furthermore, the aromatic compounds in moxa smoke may also influence the expression of neurotransmitters in the brain, normalizing their levels and facilitating the restoration of sleep.[78]

Acupuncture Combined with Western Medicine

Acupuncture combined with Western medicine appears to be the most effective treatment for reducing serum NE levels in patients with PSSD. This finding aligns with previous research,[83,84] which has demonstrated that acupuncture can significantly reduce serum NE levels in rats and improve their sleep architecture, Clinical research[85] further indicates that acupuncture therapy can lower serum NE levels in patients with insomnia, thereby enhancing sleep quality.

As a neurotransmitter, NE plays a crucial role in wakefulness by inhibiting hippocampal neurons, thereby promoting arousal.[86] Disruption of the sleep-wake cycle results in increased NE levels; conversely, normalization of the sleep-wake cycle leads to decreased NE levels, suggesting an inverse relationship between NE levels and both sleep quality and sleep duration.

Limitations of the Study

This network meta-analysis has several limitations:

(1) the inclusion of high-quality studies was limited, with many studies lacking standardized methodological designs and clear descriptions of randomization procedures, allocation concealment, and blinding, potentially introducing bias; (2) significant discrepancies existed in the number and sample sizes of studies evaluating different interventions, which may have affected the accuracy of the results; (3) due to the unique characteristics of acupuncture therapy, including variations in syndrome types, acupoints, techniques, intervention durations, and frequencies, this study did not account for these factors, potentially resulting in bias. (4) Geographical bias may also influence the results, as all included trials were conducted in China. Regional differences in clinical practices, patient demographics, and cultural attitudes toward acupuncture therapy could affect the generalizability of the findings to other populations. Future studies should aim to include more diverse populations from different geographical regions to validate the results and ensure their broader applicability. Further foundational research and multicenter, large-sample randomized controlled trials are needed to validate these findings.

Conclusion

Acupuncture therapy has shown potential efficacy in treating post-stroke sleep disorders, particularly when combined with Western medicine. The observed effects may be related to the modulation of neurotransmitter levels, including the reduction of excitatory neurotransmitters and the enhancement of inhibitory neurotransmitters. However, these findings should be interpreted with caution due to the limitations of the included studies, such as methodological heterogeneity, geographical bias, and variations in acupuncture techniques. Further high-quality, direct comparisons, multicenter randomized controlled trials are needed to confirm these results and elucidate the underlying mechanisms.

Data Sharing Statement

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

Author Contributions

Lian Jiaying: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing.

Jiang Yanhong: Investigation, Data Curation, Validation, Writing – Review & Editing.

Kong Lingli: Investigation, Data Curation, Validation, Writing – Review & Editing.

Zhou Mingqi: Writing – Original Draft, Writing – Review & Editing.

All authors contributed to the conception and design of the study. Lian Jiaying took the lead in planning the research and conducting the statistical analysis. Jiang Yanhong and Kong Lingli were responsible for the literature search, data extraction, and quality assessment. Zhou Mingqi assisted in reviewing and editing the manuscript. All authors have read and approved the final version of the manuscript, agreed on the journal to which the article will be submitted, and take full responsibility and accountability for all aspects of the work and the contents of the article.

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Disclosure

The authors declare no competing interests.

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