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Acupuncture Combined with Repetitive Transcranial Magnetic Stimulation vs Repetitive Transcranial Magnetic Stimulation Alone for Recovery of Hemiplegia After Ischemic Stroke: A Systematic Review and Meta-Analysis

Geng Li
The First Clinical Medical College, Yunnan University of Chinese Medicine https://orcid.org/0009-0003-5099-5763
Mengqi Yue
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Shuochen Fan
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Qichen Bai
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Shuai Li
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Xiaolin Yang
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Xu Chen
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Yihao Zhou
Yunnan Provincial Hospital of Traditional Chinese Medicine
Jing zhong
The Second Clinical Medical College, Yunnan University of Chinese Medicine
Jing Shi
2662831291@qq.com

Yunnan Provincial Hospital of Traditional Chinese Medicine

Systematic Review

Keywords: Hemiplegia, Acupuncture, Transcranial magnetic stimulation, Meta-analysis, Motor recovery

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Acupuncture Combined with Repetitive Transcranial Magnetic Stimulation vs Repetitive Transcranial Magnetic Stimulation Alone for Recovery of Hemiplegia After Ischemic Stroke: A Systematic Review and Meta-Analysis

Geng li[1,2+], Mengqi Yue[2+], Shuochen Fan[2+], Qichen Bai[2], Shuai Li[2], Xiaolin Yang[2], Xu Chen[2], Yihao Zhou[3], Jing zhong[2], Jing Shi[2*]

[1]The First Clinical Medical College, Yunnan University of Chinese Medicine Kunming, 650000, China

[2]The Second Clinical Medical College, Yunnan University of Chinese Medicine, Kunming 650000, China

[3]Yunnan Provincial Hospital of Traditional Chinese Medicine, Kunming 650000, China

Abstract

Objective: To compare the efficacy and safety of acupuncture combined with repetitive transcranial magnetic stimulation (rTMS) versus rTMS alone for limb recovery in patients with post-ischemic stroke hemiplegia.

Methods: Eight databases were searched up to September 25, 2025, for randomised controlled trials comparing the combination therapy with rTMS alone. Primary outcomes were motor impairment (Fugl-Meyer Assessment, FMA) and activities of daily living (Barthel Index). A random-effects model was used for meta-analyses.

Results: Thirty trials (3,261 patients) were included. Combination therapy significantly improved FMA total score (mean difference [MD] 7.11, 95% CI 5.51–8.70), FMA upper-extremity score (MD 8.21, 7.68–8.75), FMA lower-extremity score (MD 5.06, 4.42–5.71), and curative ratio (risk ratio 1.20, 1.15–1.26). Sensitivity analyses confirmed robustness. Adverse events were low and comparable between groups.

Conclusion: Acupuncture combined with rTMS is superior to rTMS alone for improving motor function and daily living activities in post-stroke hemiplegia, with a good safety profile, supporting its integration into rehabilitation paradigms.

Keywords: Hemiplegia, Acupuncture, Transcranial magnetic stimulation, Meta-analysis, Motor recovery.

Introduction

Ischemic stroke (IS) is a leading cause of long-term disability worldwide [1]. Although reperfusion therapies, including intravenous thrombolysis and endovascular thrombectomy, improve outcomes in the acute phase, functional impairments impose a substantial long-term burden [2]. Only approximately 20–30% of patients achieve complete or favourable motor recovery, with up to 50–60% persisting with limb dysfunction six months post-onset [3,4]. This severely compromises patients' activities of daily living and quality of life and imposes significant familial and socioeconomic burdens [5]. Consequently, identifying more effective rehabilitation strategies to improve post-stroke limb dysfunction remains a key clinical priority and challenge.

Research has confirmed that the recovery of upper limb function following stroke relies not only on the remodelling of the primary sensorimotor cortex (SM1) but also involves the collaborative participation of multiple brain regions, including the supplementary motor area (SMA) and premotor cortex (PMC), which form complex networks with SM1 [6]. Repetitive transcranial magnetic stimulation (rTMS), as a non-invasive neuromodulation technique, has demonstrated efficacy in improving motor function in IS patients across multiple randomised controlled trials [7,8]. However, relevant treatment guidelines indicate that the current evidence level for treating post-stroke motor deficits remains grade C, whether employing high-frequency stimulation of the ipsilateral SM1 or low-frequency stimulation of the contralateral SM1 [9]. Furthermore, rTMS efficacy exhibits marked inter-individual variability, with some patients demonstrating poor response [10], suggesting that rTMS monotherapy may have reached its efficacy ceiling.

In this context, acupuncture—a key component of traditional medicine—has gained increasing international attention for its potential role in neurological recovery [11,12]. Extensive clinical research indicates that acupuncture therapy can alleviate muscle spasticity in stroke patients with hemiplegia, enhance limb mobility and coordination, and improve performance in daily living ac

tivities [13,14]. Nevertheless, acupuncture therapy also faces challenges. Its mechanisms of action remain incompletely elucidated, and the lack of standardised treatment protocols leads to inconsistent reproducibility of therapeutic outcomes[15]. Despite these challenges, its consistent reporting of clinical benefits warrants further investigation, particularly as a component of combination therapy.

Given the complementary strengths and limitations of rTMS and acupuncture, their combined application is theoretically grounded. As a precise central intervention, rTMS can remodel post-stroke imbalances in interhemispheric inhibition by modulating cortical excitability [16]. Conversely, acupuncture stimulates limb acupoints to generate dense peripheral sensory input, thereby broadly activating sensorimotor networks in a bottom-up manner [17]. We conducted this systematic review and meta-analysis to evaluate the efficacy and safety of combined acupuncture and rTMS versus rTMS alone for motor recovery in post-stroke hemiplegia. The pooled results demonstrate that the combination therapy is superior to rTMS monotherapy, with significant improvements in motor function and activities of daily living, and a favourable safety profile. These findings support the integration of acupuncture into conventional rTMS-based rehabilitation paradigms.

Materials and methods

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and were prospectively registered (CRD420251155831).

Search strategy

A systematic literature search was performed in the following electronic databases: Medline, Embase, the Cochrane Central Register of Controlled Trials (CENTRAL), Web of Science (SCI), Chinese Biomedical Database (CBM), Chinese National Knowledge Infrastructure (CNKI), Wan Fang Data Knowledge Service Platform, and VIP Journal Integration Platform (VIP). The databases were searched from inception to September 25, 2025. The search strategy employed combined controlled vocabulary with free-text terms pertaining to “ischemic stroke”, “hemiplegia”, “acupuncture”, and “repetitive transcranial magnetic stimulation”. The complete search strategy is detailed in the Supplementary Appendix [18].

Inclusion Criteria

Studies were selected based on the PICOS framework:

(1) Population: Adult patients (≥18 years) with a clinical and radiological (CT/MRI) diagnosis of ischemic stroke, presenting with hemiplegia or unilateral motor impairment.
(2) Intervention: Acupuncture combined with rTMS.
(3) Comparison: rTMS alone or rTMS plus sham/superficial acupuncture.
(4) Outcomes: The primary outcome was motor impairment, quantified by the Fugl-Meyer Assessment total score (FMA-Total) and its upper-extremity (FMA-UE) and lower-extremity (FMA-LE) subscales.
(5) Study design: Randomized controlled trials (RCTs).

Exclusion criteria

Studies were excluded if they were: (1) duplicate publications; (2) control interventions involved any form of authentic acupuncture therapy; (3) animal studies; or (4) full text was unavailable.

Study selection and data extraction

Two reviewers independently evaluated titles, abstracts, and full-text papers according to the eligibility criteria. Disagreements were settled through dialogue or by seeking the opinion of a third reviewer. Data were extracted independently by the two reviewers using a pre-designed, piloted data extraction form. Extracted data included study characteristics, participant demographics, intervention details, outcome measures, and results.

Study quality assessment

The Cochrane Risk of Bias 2.0 tool was employed to evaluate the quality of individual studies. The evaluation encompasses five fundamental domains: (1) randomization method; (2) divergence from the intervention; (3) absence of outcome data; (4) outcome measurement; (5) selective reporting of findings. The risk of bias in each domain will be evaluated as low, high, or uncertain,

informing the study's overall risk assessment. Two researchers (MQ-Y and XC) conducted independent evaluations to ensure rigor and objectivity. Initial scoring discrepancies were resolved through consensus discussion; unresolved disagreements were arbitrated by a senior methodological expert (YH-Z), who also performed the final consistency review of all assessment outcomes.

Types of outcomes

The primary outcome was the change in motor function, assessed by the FMA-Total, FMA-UE, and FMA-LE. Secondary outcomes included: functional independence measured by the Barthel Index (BI), and the curative ratio (as defined by the original studies, typically the proportion of patients achieving 'marked improvement' or 'cure' based on predefined criteria).

Statistical analysis

All statistical analyses were performed using R software (version 4.5.1). For continuous outcomes, the pooled effect was expressed as the mean difference (MD) with a 95% confidence interval (CI); for dichotomous outcomes, it was expressed as the risk ratio (RR) with a 95% CI. A random-effects model was employed for all meta-analyses. Heterogeneity was quantified using the I^2 statistic, with values of 25%, 50%, and 75% representing low, moderate, and high heterogeneity, respectively. The statistical significance of the pooled effect estimates was assessed with Z-tests, using a two-sided P-value < 0.05 as the threshold. To evaluate robustness, sensitivity analyses were conducted using the leave-one-out method. Potential publication bias was assessed for the primary outcomes through visual inspection of funnel plots and Egger's linear regression test ($P < 0.10$ indicating statistical significance for the test of small-study effects).

Pre-planned subgroup analyses were performed to explore potential sources of heterogeneity. For FMA-UE, subgroups were defined by acupuncture technique (manual, electroacupuncture, warm), treatment frequency (5 vs. 6 sessions/week), treatment duration (4 weeks vs. >4 weeks), and baseline severity (FMA-UE <28 vs. ⩾28). For FMA-LE, subgroups were defined by acupuncture technique (manual vs. warm), treatment frequency, and treatment duration. For Barthel Index, subgroups were defined by treatment frequency, treatment duration, and baseline dependency (BI <40 vs. ⩾40). Subgroup differences were assessed using a random-effects meta-regression mod

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el; a P-value <0.05 was considered significant. Given the exploratory nature and limited study nu mbers per stratum, all subgroup analyses should be interpreted cautiously.

Results

Research characteristics

The systematic literature search identified 512 records. After removal of duplicates, 293 reco rds underwent title and abstract screening, of which 252 were excluded. The remaining 41 articles were assessed in full text, and 30 randomized controlled trials (RCTs) met the eligibility criteria and were included in the meta-analysis [19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,3 7,38,39,40,41,42,43,44,45,46,47,48]. (Figure 1)

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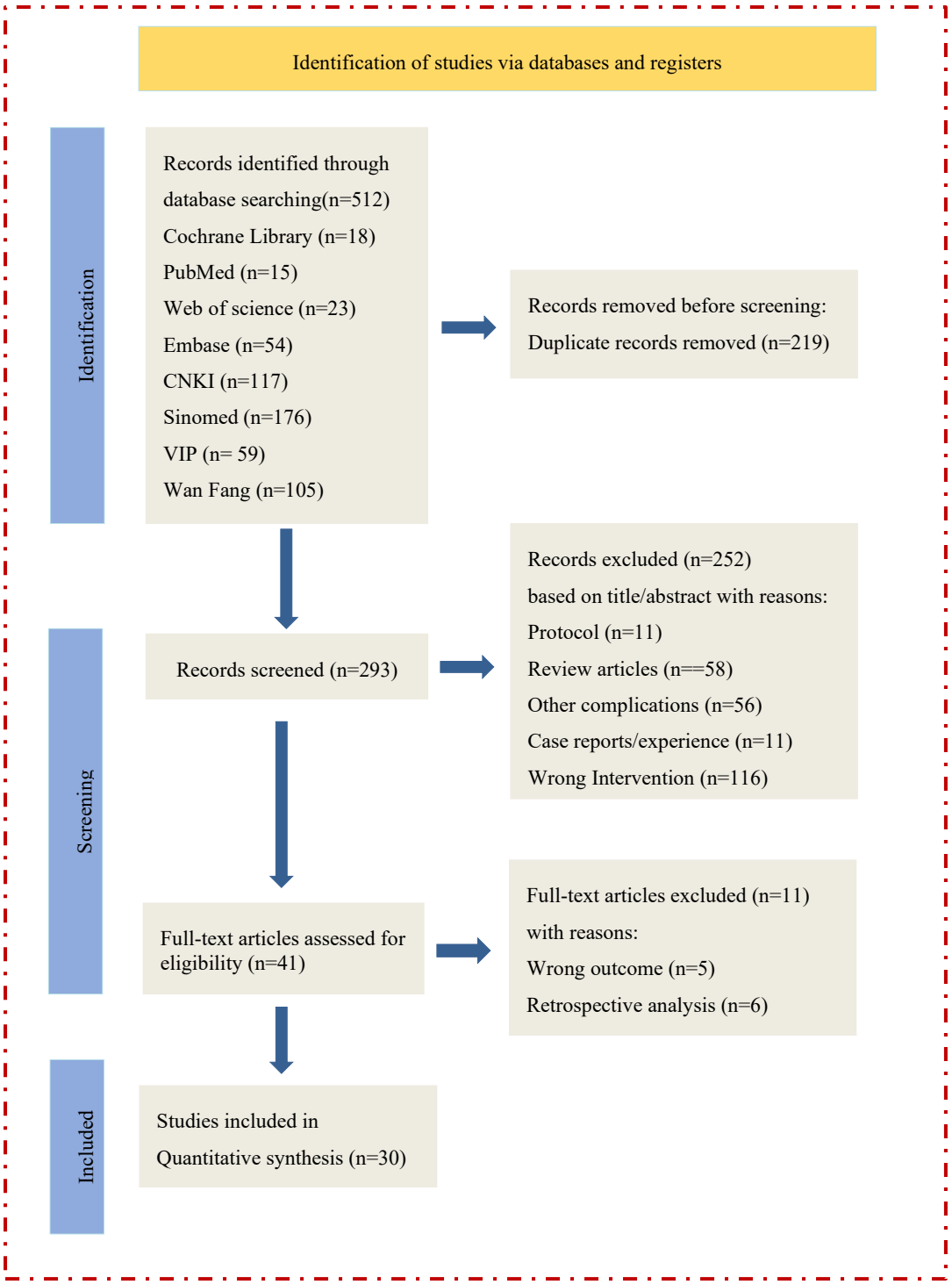


Figure 1. Literature Screening Flowchart

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Table 1 presents the fundamental characteristics of all research. We examined baseline data prior to the intervention, including the mean age, gender, and disease duration. Post-intervention data encompassed diagnostic criteria, intervention methods, treatment duration, outcome measures, and adverse events. Participants' mean age ranged from 50 to 72 years. All 30 trials described patient gender, with male participants predominating in the majority. Twenty-six trials reported disease duration, while four trials [21,26,31,47] omitted this information. All studies reported treatment duration, which varied between 21 and 90 days. Only three studies [41,42,44] mentioned adverse reactions in the acupuncture group, including fever, pain at the needle insertion site, and numbness. All patients tolerated these reactions, and none withdrew from the trial due to these adverse effects.

Table 2 presents the characteristics of interventions across all studies. Manual acupuncture (MA) was the most frequently employed technique (n = 24), followed by electroacupuncture (EA) (n = 3) and warm acupuncture (WA) (n = 3). Among the 30 studies, 17 set the needle retention time at 30 minutes, 7 at 20 minutes, and 1 did not specify a retention time [27], while the remaining studies varied between 40 minutes and 8 hours. The frequency of treatment varied between 3 and 7 sessions weekly, with a mean of 5 sessions (n = 17). Treatment durations in all studies varied from 4 to 12 weeks, with 4 weeks being the most chosen duration (n = 20). The included studies noted the following points and frequencies: Zusanli (n = 25), Hegu (n = 23), Baihui (n = 16), and Quchi (n = 16) were the most frequently utilised acupoints.

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Table 1: Attributes of the studies included.

Trial Name	Simple Size	Sex (male/female)	Age (years)	Disease Course (mouth)	Therapy duration (mouth)	Source of diagnostic criteria	Outcomes measures	Adverse reactions
Cao, 2022 [19]	I: 30/30 C: 30/30	I: 13/17 C: 16/14	I: 56.90±4.70 C: 55.10±3.20	I: 2.17±1.16 C:2.29±0.88	1	CT/MRI	Broetz scale, hemiplegic hand function grading scale, BI	Not Shown
Zhao, 2024 [20]	I: 30/32 C: 30/31	I: 19/11 C: 20/10	I: 65.20±8.50 C: 63.40±13.30	I: 0.23±0.07 C: 0.23±0.07	3	Chinese expert consensus standards	NIHSS, FMA, BI, MEP	Not Shown
Li, 2022 [21]	I: 75/75 C: 75/75	I: 38/37 C: 36/39	I: 57.53±4.28 C: 58.42±5.43	NR	1	Chinese expert consensus standards	FMA, FIM, NIHSS, BSS	Not Shown
Gong, 2024 [22]	I: 30/30 C: 30/30	I: 15/15 C: 17/13	I: 59.1±3.49 C: 57.95±3.40	I: 1.73±0.30 C: 1.71±0.28	1.5	CT/MRI	FMA, BI, HFAC, BBS	Not Shown
Dang, 2023 [23]	I: 49/50 C: 48/50	I: 30/20 C: 28/22	I: 71.89±7.62 C: 72.42±8.14	I: 0.81±0.18 C: 0.84±0.19	1	CT/MRI	FMA, NIHSS, ADL, MEP, CMCT	Not Shown
Zhang, 2018 [24]	I: 50/50 C: 50/50	I: 34/16 C: 33/17	I: 55.90±7.50 C: 56.40±7.10	I: 2.70±0.70 C: 2.60±0.90	2.5	CT/MRI	FMA, NIHSS, HFAC, BI	Not Shown
Lin, 2019 [25]	I: 50/50 C: 50/50	I: 28/22 C: 29/21	I: 50.00±4.00 C: 51.00±4.00	I: 1.12±0.15 C: 1.09±0.22	1	CT/MRI	NIHSS, FMA, MBI, SAS, SDS	Not Shown
Zhou, 2022 [26]	I: 54/54 C: 55/55	I: 29/26 C: 29/25	I: 64.91±7.35 C: 65.38±7.34	NR	2	CT/MRI	FMA, NIHSS, BI, CRP, TNF-α, LT-6, NSE, MBP	Not Shown
Zhang, 2024 [27]	I: 45/45 C: 45/45	I: 26/19 C: 24/21	I: 66.51±9.34 C: 65.63±8.58	I: 2.32±0.73 C: 2.27±0.76	1	CT/MRI	FMA, GFAP, MBP, GABA, Glu	Not Shown
Yan, 2025 [28]	I: 36/36 C: 36/36	I: 23/13 C: 26/10	I: 59.50±9.87 C: 61.03±10.95	I: 1.93±0.49 C: 1.92±0.52	1	Chinese expert consensus standards	FMA, ARAT, mRS	Not Shown
Hou, 2025 [29]	I: 60/60 C: 60/60	I: 38/22 C: 39/21	I: 62.25±4.23 C: 62.32±4.38	I: 6.52±1.96 C: 6.43±2.03	1	CT/MRI	FMA, ADL, Vm, Ri, Vs	Not Shown

Zhang, 2025 [30]	I: 53/53 C: 53/53	I: 26/27 C: 29/24	I: 65.01±6.13 C: 63.69±7.84	I: 1.56±0.34 C: 1.50±0.35	1	CT/MRI	MAS, FMA, BI, EEG	Not Shown
Zuo, 2024 [31]	I: 30/30 C: 30/30	I: 19/11 C: 18/12	I: 66.95±6.47 C: 66.56±6.09	NR	2	CT/MRI	FMA, ADL, MMSE, VM, VS	Not Shown
Yu, 2023 [32]	I: 36/36 C: 36/36	I: 22/14 C: 23/13	I: 58.9±6.7 C: 57.6±6.4	I: 1.61±0.45 C: 1.58±0.42	1	CT/MRI	FMA, WMFT, MBI	Not Shown
Zhu, 2017 [33]	I: 20/20 C: 20/20	I: 11/9 C: 9/11	I: 64.23±10.54 C: 61.00±11.68	I: 1.15±0.39 C: 1.24±0.49	1	Chinese expert consensus standards	FMA, WMFT	Not Shown
Yue, 2025 [34]	I: 44/46 C: 44/46	I: 24/20 C: 26/18	I: 63.08±8.55 C: 61.75±7.62	I: 2.95±0.72 C: 3.06±0.95	2	CT/MRI	NIHSS, FMA, Gait parameters	Not Shown
Li, 2024 [35]	I: 75/75 C: 75/75	I: 40/35 C: 42/33	I: 50.26±1.31 C: 50.17±1.25	I: 3.10±0.12 C: 3.08±0.15	1	Chinese expert consensus standards	NIHSS, FMA, VM	Not Shown
Wan, 2025 [36]	I: 40/40 C: 40/40	I: 25/15 C: 22/18	I: 60.41±2.45 C: 60.35±2.48	I: 7.18±1.46 C: 7.26±1.34	3	Chinese expert consensus standards	FMA, NIHSS, BBS, SS-QOL, EEG	Not Shown
Ji, 2021 [37]	I: 30/30 C: 30/30	I: 17/13 C: 16/14	I: 55.5±3.7 C: 55.3±3.2	I: 2.9±0.20 C: 2.7±0.30	0.75	Chinese expert consensus standards	FMA, BI, NIHSS	Not Shown
Zhang, 2022 [38]	I: 36/36 C: 36/36	I: 25/11 C: 22/14	I: 60.98±2.11 C: 61.21±2.24	I: 0.11±0.02 C: 0.11±0.02	1	CT/MRI	FMA, NIHSS, BI	Not Shown
Cao, 2023 [39]	I: 51/51 C: 51/51	I: 27/24 C: 30/21	I: 60.13±6.31 aC: 59.84±6.25	I: 0.63±0.10 C: 0.61±0.10	1	CT/MRI	FMA, BBS, MMT	Not Shown
Xie, 2024 [40]	I: 30/30 C: 30/30	I: 19/11 C: 20/10	I: 60.25±5.13 C: 60.21±5.11	I: 5.25±1.21 C: 5.21±1.25	1	Chinese expert consensus standards	FMA, MAS	Not Shown
Liu, 2023 [41]	I: 60/60 C: 60/60	I: 36/24 C: 35/25	I: 57.83±5.64 C: 58.42±6.33	I: 6.04±2.15 C: 6.13±1.87	3	CT/MRI	FMA, NIHSS, SS-QOL	Headache, pain in the scapular region, constipation, and limb edema.
Gao, 2025 [42]	I: 58/58 C: 58/58	I: 32/26 C: 24/34	I: 69.88±6.43 C: 70.73±6.98	I: 6.33±1.42 C: 6.20±1.65	1	CT/MRI	FMA, NSE, GFAP, S100-β,	Nausea and vomiting,

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							SS-QOL	dizziness and fatigue, localized stabbing pain, rash and pruritus.
Wang, 2024 [43]	I: 69/69 C: 68/68	I: 41/28 C: 42/26	I: 62.68±8.21 C: 62.49±8.18	I: 1.37±0.42 C: 1.35±0.41	1	Chinese expert consensus standards	FMA, SF-36, BDNF, NGF, NT3	Not Shown
Huo, 2025 [44]	I: 41/41 C: 41/41	I: 33/8 C: 30/11	I: 61.57±6.44 C: 62.05±6.49	I: 1.09±0.16 C**:**1.06±0.16	1	CT/MRI	FMA, EEG	Headache, pain in the scapular region, constipation, and limb edema.
Cheng, 2025 [45]	I: 48/48 C: 48/48	I: 26/22 C: 20/28	I: 54.26±3.12 C: 54.85±4.11	I: 1.57±0.47 C: 1.60±0.47	3	Chinese expert consensus standards	FMA, CSI, BSS, SDSS, QOLI	Not Shown
Fu, 2024 [46]	I: 63/63 C: 63/63	I: 41/22 C: 39/24	I: 59.40± 8.00 C: 58.00±7.90	I: 4.75±2.06 C: 4.69±2.18	1	CT/MRI	BRS, FMA, MBI	Not Shown
Deng, 2022 [47]	I: 48/48 C: 48/48	I: 37/11 C: 34/14	I: 67.26±1.84 C: 67.18±1.79	NR	1	CT/MRI	FMA, BBS, BI	Not Shown
Zhu, 2024 [48]	I: 34/34 C: 37/37	I: 20/14 C: 25/12	I: 58.74±7.45 C: 57.12±7.24	I: 1.95±0.27 C: 1.86±0.28	1.5	CT/MRI	FMA, MAS, MBI, BRS	Not Shown

(BI: Barthelindex, NIHSS:The National Instiutes of Health stroke scale, FMA:Fugl-Meyerassessment, MEP: motorevoked potential, FIM: Functional Independence Measure，BSS: Berg Balance Scale, HFAC: Holden Functional Ambulation Classification, CMCT: Central motor conduction time, SAS: Self-rating Anxiety Scale，SDS: Self-rating Depression Scale, CRP: C-reactive Protein, TNF-α: Tumor Necrosis Factor-alpha, IL-6: Interleukin-6, NSE: Neuron-Specific Enolase, MBP: Myelin Basic Protein, GFAP: Glial Fibrillary Acidic Protein, GABA: Gamma-Aminobutyric Acid, Glu: Glutamate, ARAT: Action Research Arm Test, mRS: Modified Rankin Scale, ADL: Activities of Daily Living, Vm: Mean Blood Flow Velocity, RI: Resistance Index, Vs: Peak Systolic Velocity, MAS: Modified Ashworth Scale, MMSE: Mini-Mental State Examination, WMFT: Wolf Motor Function Test, S100β: S100 Calcium-Binding Protein Beta, SS-QOL: Stroke-Specific Quality of Life Scale, MMT: Manual Muscle Testing, SF-36: Medical Outcomes Study 36-Item Short-Form Health Survey, CSI: Clonus Spasm Index, SDSS: Social Disability Screening Schedule, QOLI: Quality of Life Index, BRS: Brunnstrom Recovery Stage, RMS: Root Mean Square, CR: Co-contraction Ratio, EMG: Electromyography, BDNF: Brain-Derived Neurotrophic Factor, NGF: Nerve Growth Factor, NT3: Neurotrophin-3)

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215 Table 2: Details of the interventions in the analyzed studies.

Study	Acupuncture methods		Treatment duration		
	Style	Acupoint selection	Frequency	Retained	Course
Cao, 2022 [19]	MA	Da-ling (PC7), Lao-gong (PC8), San-Jian (LI3), Hou-xi (SI3), Wai-lao-gong (EX-UE8), Shi-xuan (EX-UE11)	4 times/w	30min	1 month
Zhao, 2024 [20]	EA	Qu-Chi (LI11), Shou-San-li (LI10), He-gu (LI4), Yang-xi (LI5), Liang-qiu (ST34), Zu-san-li (ST36), Guan-yuan (RN4), Zhong-wan (CV12), Bai-hui (DU20), Da-Zhu (BL11)	5 times/w	30min	3 months
Li, 2022 [21]	MA	Qu-Chi (LI11), He-gu (LI4), Wai-guan (SJ5), Shou-San-li (LI10), Jian-Yu (LI15), Zu-san-li (ST36), Tai-chong (LR3), Fu-Tu (LI18), Jie-Xi (ST41), Bi-Guan (ST31)	5 times/w	20min	1 month
Gong, 2024 [22]	MA	Bai-hui (DU20), San-yin-jiao (SP6), Qu-Chi (LI11), Zu-san-li (ST36), Wai-guan (SJ5), Jian-Yu (LI15)	5 times/w	30min	6 weeks
Dang, 2023 [23]	MA	Bai-hui (DU20), San-yin-jiao (SP6), He-gu (LI4), Qu-Chi (LI11), Nei-guan (PC6), Zu-san-li (ST36),	6 times/w	30min	1 month
Zhang, 2018 [24]	MA	Shui-Gou (DU26), Nei-guan (PC6), San-yin-jiao (SP6), Wei-zhong (BL40), Ji-quan (HT1), Chi-Ze (LU5)	5 times/w	30min	10 weeks
Lin, 2019 [25]	MA	Bai-hui (DU20), Shui-Gou (DU26), Nei-guan (PC6), Ji-quan (HT1), Zu-san-li (ST36), Jian-Yu (LI15), He-gu (LI4), Huan-Tiao (GB30), Yang-Ling-Quan (GB34),	7 times/w	30min	1 month
Zhou, 2022 [26]	MA	Bai-hui (DU20), Jian-Yu (LI15), San-yin-jiao (SP6), Shou-San-li (LI10), Wai-guan (SJ5), He-gu (LI4), Qu-Chi (LI11), Fu-Tu (LI18), Yang-Ling-Quan (GB34), Zu-san-li (ST36), Tai-chong (LR3), Lian-quan (RN23), Feng-chi (GB20), Tian-zhu (BL10), Ya-Men (DU15), Jia-Che (ST6), Ying-Xing (LI20), Di-Cang (ST10)	5 times/w	30min	2 months
Zhang, 2024 [27]	MA	Nei-guan (PC6), San-yin-jiao (SP6), Ji-quan (HT1), Chi-Ze (LU5), Wei-zhong (BL40), He-gu (LI4), Feng-chi (GB20)	5 times/w	NR	1 month
Yan, 2025 [28]	EA	Jian-Yu (LI15), Jian-liao (SJ14), Qu-Chi (LI11), Wai-guan (SJ5), He-gu (LI4), Bi-Guan (ST31), Xue-hai (SP10), Zu-san-li (ST36), Yang-Ling-Quan (GB34), Jue-gu (GB39), Tai-chong (LR3),	6 times/w	40min	1 month
Hou, 2025 [29]	MA	Bai-hui (DU20), Si-shen-cong (EX-HN1), Qu-Chi (LI11), He-gu (LI4), Feng-shi (GB31), Zu-san-li (ST36), San-yin-jiao (SP6), Jian-liao (SJ14), Shou-San-li (LI10), Nei-guan (PC6), Yang-lao (SI6), Hou-xi (SI3), Xue-hai (SP10), Yang-Ling-Quan (GB34), Jie-Xi (ST41), Tai-chong (LR3)	5 times/w	30min	1 month
Zhang, 2025 [30]	MA	Zu-san-li (ST36), Xia-ju-xu (ST39), Yang-Ling-Quan (GB34), Qiu-xu (GB40), Wei-zhong (BL40), Cheng-jin (BL56), Kunlun (BL60	3 times/w	20min	1 month
Zuo, 2024 [31]	MA	Bai-hui (DU20), Feng-chi (GB20), Tong-zi-liao (GB1), Yang-Ling-Quan (GB34), Guang-ming (GB37), Zu-san-li (ST36), Feng-long (ST40), Cuan-zhu (BL2), Shou-	5 times/w	30min	2 months

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		San-li (LI10), Qu-Chi (LI11), He-gu (LI4)			
Yu, 2023 [32]	MA	Bai-hui (DU20), Si-shen-cong (EX-HN1), Jian-Yu (LI15), Binao (LI14), Zhou-liao (LI12), Qu-Chi (LI11), Shou-San-li (LI10), Wai-guan (SJ5), Yang-xi (LI5), He-gu (LI4)	6 times/w	20min	1 month
Zhu, 2017 [33]	MA	NR	5 times/w	20min	1 month
Yue, 2025 [34]	MA	Ji-quan (HT1), Chi-Ze (LU5), Xue-hai (SP10), Qi-hai (RN6), Zu-san-li (ST36), San-yin-jiao (SP6),	5 times/w	30min	2 months
Li, 2024 [35]	MA	Nei-guan (PC6), Shui-Gou (DU26), San-yin-jiao (SP6), Wei-zhong (BL40), Ji-quan (HT1), Qiu-xu (GB40), Zhao-hai (KI6)	6 times/w	30min	1 month
Wan, 2025 [36]	WA	Wai-guan (SJ5), He-gu (LI4), Qu-Chi (LI11), Jian-Yu (LI15), Shou-San-li (LI10), Liang-qiu (ST34), Kunlun (BL60), Yang-Ling-Quan (GB34), Zu-san-li (ST36)	5 times/w	20min	3 months
Ji, 2021 [37]	MA	NR	5 times/w	8hour	1 month
Zhang, 2022 [38]	MA	Zu-san-li (ST36), Yang-Ling-Quan (GB34), San-yin-jiao (SP6), He-gu (LI4), Nei-guan (PC6), Qu-Chi (LI11)	5 times/w	20min	1 month
Cao, 2023 [39]	MA	Zu-san-li (ST36), Yang-Ling-Quan (GB34), San-yin-jiao (SP6), He-gu (LI4), Nei-guan (PC6), Qu-Chi (LI11)	3 times/w	30min	1 month
Xie, 2024 [40]	MA	Shui-Gou (DU26), Bai-hui (DU20), Ji-quan (HT1), Nei-guan (PC6), Zu-san-li (ST36), Jian-Yu (LI15), He-gu (LI4)	7 times/w	30min	1 month
Liu, 2023 [41]	WA	Shou-San-li (LI10), Qu-Chi (LI11), Wai-guan (SJ5), Jian-Yu (LI15), He-gu (LI4), Zu-san-li (ST36), Kunlun (BL60), Liang-qiu (ST34), Yang-Ling-Quan (GB34)	5 times/w	40min	3 months
Gao, 2025 [42]	MA	Ji-quan (HT1), Chi-Ze (LU5), Nei-guan (PC6), San-yin-jiao (SP6), Yin-Ling-Quan (SP9)	5 times/w	30min	1 month
Wang, 2024 [43]	WA	NR	6 times/w	60min	1 month
Huo, 2025 [44]	MA	Tai-yuan (LU9), Wai-guan (SJ5), Nei-guan (PC6), Shou-San-li (LI10), Qu-Chi (LI11), Jian-Yu (LI15), Jian-liao (SJ14), Zu-san-li (ST36), Xuan-zhong (GB39), Jian-zhen (SI9), Qi-hai (RN6), Guan-yuan (RN4)	5 times/w	30min	1 month
Cheng, 2025 [45]	MA	Shui-Gou (DU26), Bai-hui (DU20), Tian-zong (SI11), Tai-chong (LR3), Jian-Yu (LI15), Lao-gong (PC8), Shen-men (HT7), He-gu (LI4), Yong-quan (KI1), He-gu (LI4), Qu-Chi (LI11), Zhi-zheng (SI7), Wai-guan (SJ5), Lie-que (LU7), Shou-wu-li (LI13), Shou-San-li (LI10), Feng-chi (GB20), Tai-xi (KI3), Zhao-hai (KI6), Feng-long (ST40), San-yin-jiao (SP6), Yin-Ling-Quan (SP9), Xue-hai (SP10), Yang-Ling-Quan (GB34), Qi-hai (RN6), Guan-yuan (RN4), Huan-Tiao (GB30), Fu-Tu (LI18), Nei-ting (ST44)	7 times/w	30min	3 months
Fu, 2024 [46]	MA	Tai-bai (SP3), Shao-fu (HT8), Shu-gu (BL65), Zu-tong-gu (BL66), Da-zhu (BL11), Tian-zhu (BL10), Zu-san-li (ST36), Zhang-men (LR13), Zhong-wan (RN12), Kunlun (BL60), Bai-hui (DU20)	6 times/w	40min	1 month
Deng, 2022 [47]	MA	Nei-guan (PC6), Shui-gou (DU26), San-yin-jiao (SP6), Tian-zhu (BL10), He-gu (LI4), Feng-chi (GB20), Ji-quan (HT1), Chi-Ze (LU5), Wan-gu (GB12)	5 times/w	30min	1 month

13

Zhu, 2024 [48]	EA	Bai-hui (DU20), Si-shen-cong (EX-HN1), Jian-liao (SJ14), Ji-quan (HT1), Qu-Chi (LI11), Nei-guan (PC6), He-gu (LI4), Huan-Tiao (GB30), Liang-qiu (ST34), Zu-san-li (ST36), Cheng-fu (BL36), Tai-xi (KI3), Shou-San-li (LI10), Jian-zhen (SI9), Wai-guan (SJ5)	6 times/w	20min	6weeks

(MA: manual acupuncture; WA: warm acupuncture; EA: Electroacupuncture)

14

Risk of bias in the studies

The summary of bias risk in the included RCTs, evaluated with the Cochrane RoB 2 methodology, is illustrated in Figure 2. Most research did not reveal a significant risk of bias in the randomization method. Nevertheless, four trials [26,37,45,48] just used the term 'random' without detailing the methodology for creating random sequences. Consequently, they were evaluated as possessing an ambiguous risk of bias. Two trials, [36, 44], were randomized based on therapy type and were consequently evaluated as having a high risk of bias. Of the 30 investigations, three [20,23,34] were evaluated as having a significant risk of deviating from the targeted intervention due to their failure to analyze cases lost to follow-up. All studies were assessed to exhibit a minimal risk of data omission. Conversely, apprehensions over result measurement emerged in all 30 investigations, as outcome assessors were cognizant of the interventions administered to participants, potentially biasing the outcome assessment. All qualifying studies were assessed to exhibit a minimal risk of bias in selecting reported results. (Figure 3)

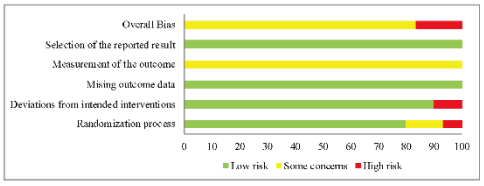


Figure 2. Risk of bias summary.

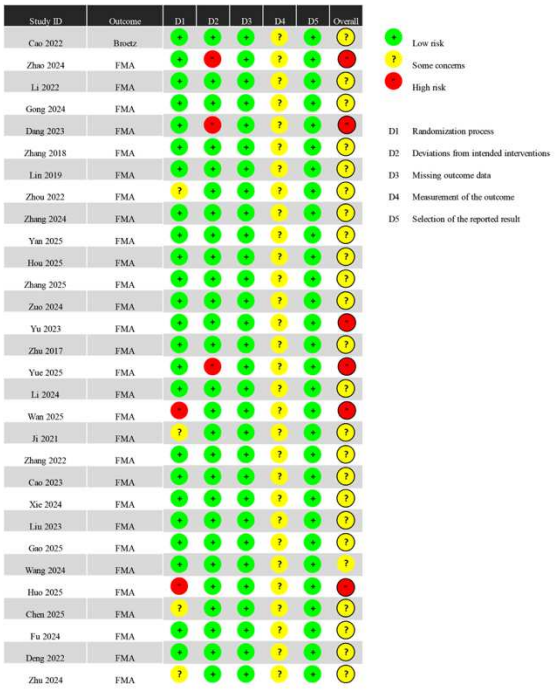


Figure 3. Risk of bias graph.

Meta-analysis of the results

FMA Total Score

Seven trials [23,25,31,38,39,43,46] reported outcomes using the FMA-Total score. 673 individuals were included, including 337 in the combination therapy group and 336 in the rTMS control group. The pooled analysis indicated that combination therapy was associated with greater improvement in FMA-Total scores relative to rTMS alone (MD 7.11; 95% CI 5.51 to 8.70; $P < 0.001$; $I^2 = 48.30\%$; Figure 4).

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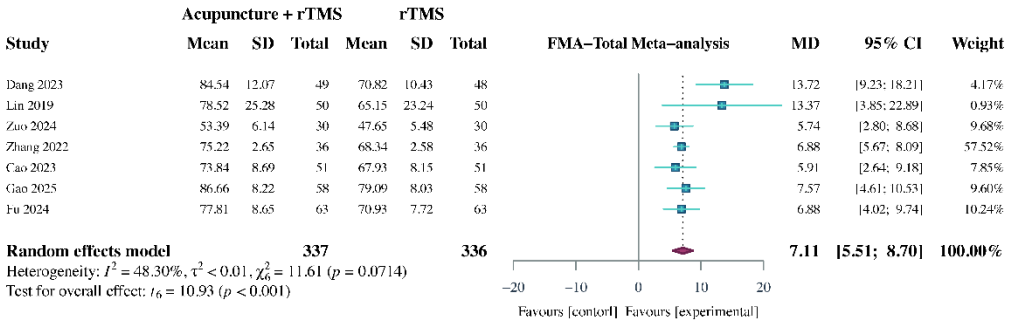


Figure 4. Forest plot illustrating the effects of acupuncture in conjunction with rTMS compared to rTMS alone on FMA-Total.

FMA-UE

Sixteen trials [21,23,26,27,28,29,32,34,35,36,37,41,42,43,47,48] identified FMA-UE as an o utcome measure. 1,628 patients were included, including 813 in the combination therapy group a nd 815 in the rTMS control group. Initial analysis demonstrated that combined acupuncture thera py was associated with significantly greater improvement in FMA-UE scores in stroke patients re lative to rTMS alone (MD 8.60, 95% CI 7.03–10.17, P < 0.001) (Figure 5A). However, substantia l heterogeneity existed between studies. Systematic outlier identification and influence analysis re vealed two studies, [29,35], as primary sources of this heterogeneity. Exclusion analysis further c onfirmed this, with substantial reductions in heterogeneity measures (I^2 and τ^2) following their re moval (Figure 5B). In the sensitivity analysis excluding these two outlier studies, the pooled effec t size based on the remaining 14 studies remained statistically significant (MD = 8.21, 95% CI 7.6 8–8.75, P < 0.0001), with no observed heterogeneity. This sensitivity analysis confirms that the o verall findings are not driven solely by these two studies and supports the robustness of the treatm ent effect (Figure 5C).

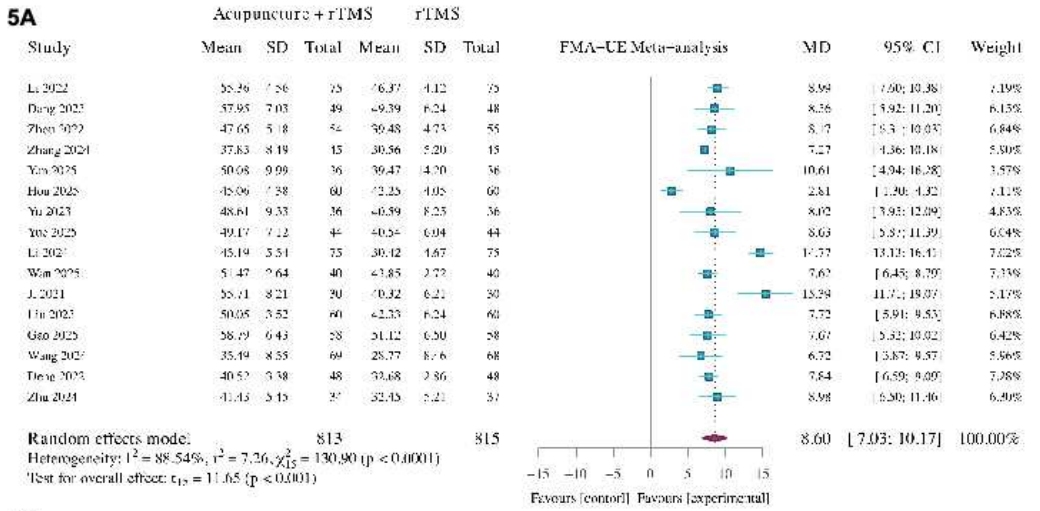
To explore the substantial heterogeneity in the initial FMA-UE analysis (I^2 >90%), we perfor med subgroup analyses by acupuncture technique, treatment frequency, duration and baseline sev erity. Manual acupuncture (MA; 11 studies) yielded an effect of (MD = 8.84, 95% CI [6.78, 10.9 0], I^2 = 92.1%), electroacupuncture (EA; 2 studies) (MD = 9.24, 95% CI [6.97, 11.52], I^2 = 0%), a nd warm acupuncture (WA; 3 studies) (MD = 7.55, 95% CI [6.62, 8.48], I^2 = 0%). For treatment f requency, 5 sessions/week (10 studies) gave (MD = 7.99, 95% CI [6.32, 9.66], I^2 = 85.2%) and 6

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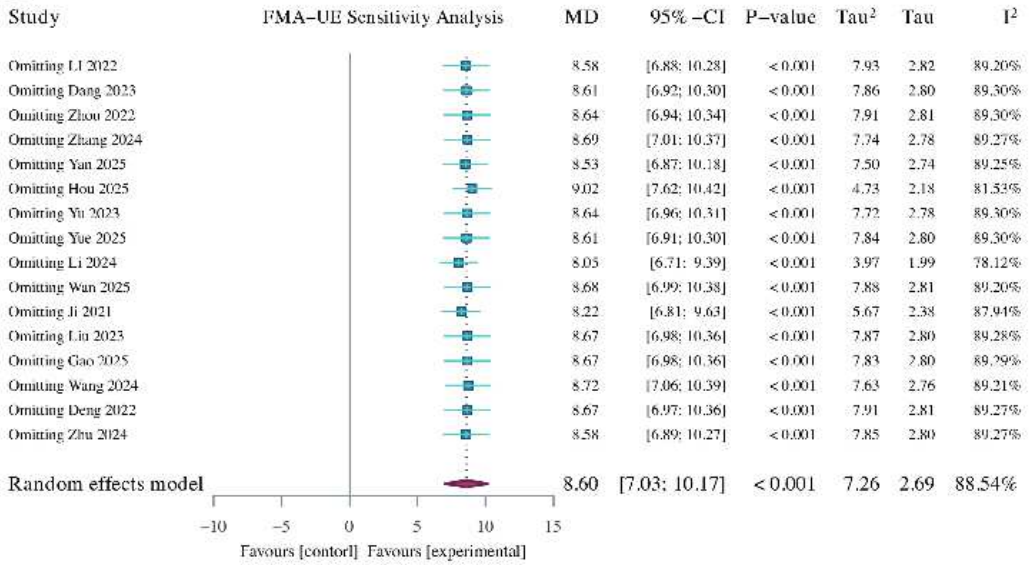
sessions/week (6 studies) gave (MD = 9.73, 95% CI [7.11, 12.35], I^2 = 86.4%). Regarding treatme nt duration, 4-week regimens (11 studies) showed (MD = 8.85, 95% CI [6.67, 11.03], I^2 = 92.2%), while longer than 4 weeks (5 studies) gave (MD = 7.96, 95% CI [7.17, 8.74], I^2 = 0%). When stra tified by baseline severity, patients with severe impairment (FMA-UE <28; 8 studies) had (MD = 9.53, 95% CI [7.25, 11.82], I^2 = 89.5%), whereas those with mild-to-moderate impairment (≥28; 8 studies) had (MD = 7.51, 95% CI [5.80, 9.22], I^2 = 81.6%).

18

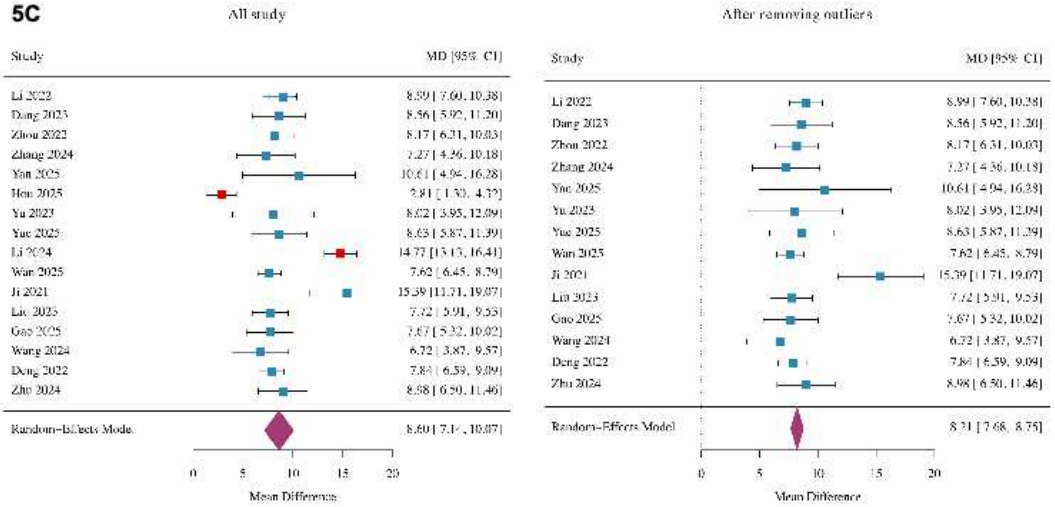
5A


Acupuncture + rTMS
rTMS
Study
Mean
SD
Total
Mean
SD
Total
FMA-UE Meta-analysis
MD
95% CI
Weight
Li 2022
Dang 2023
Zhou 2022
Zhang 2024
Yan 2025
Hou 2025
Yu 2023
Yue 2025
Li 2024
Wan 2025
Ji 2021
Liu 2023
Gao 2025
Wang 2024
Deng 2022
Zhu 2024
Random effects model
813
815
8.60
[7.03; 10.17]
100.00%
Heterogeneity: I^2 = 88.54%, τ^2 = 7.26, χ^2_{15} = 130.90 (p < 0.0001)
Test for overall effect: t_{15} = 11.65 (p < 0.001)
−15
−10
−5
0
5
10
15
Favours [control]
Favours [experimental]

5B


Study
FMA-UE Sensitivity Analysis
MD
95% -CI
P-value
Tau²
Tau
I²
Omitting LI 2022
8.58
[6.88; 10.28]
< 0.001
7.93
2.82
89.20%
Omitting Dang 2023
8.61
[6.92; 10.30]
< 0.001
7.86
2.80
89.30%
Omitting Zhou 2022
8.64
[6.94; 10.34]
< 0.001
7.91
2.81
89.30%
Omitting Zhang 2024
8.69
[7.01; 10.37]
< 0.001
7.74
2.78
89.27%
Omitting Yan 2025
8.53
[6.87; 10.18]
< 0.001
7.50
2.74
89.25%
Omitting Hou 2025
9.02
[7.62; 10.42]
< 0.001
4.73
2.18
81.53%
Omitting Yu 2023
8.64
[6.96; 10.31]
< 0.001
7.72
2.78
89.30%
Omitting Yue 2025
8.61
[6.91; 10.30]
< 0.001
7.84
2.80
89.30%
Omitting Li 2024
8.05
[6.71; 9.39]
< 0.001
3.97
1.99
78.12%
Omitting Wan 2025
8.68
[6.99; 10.38]
< 0.001
7.88
2.81
89.20%
Omitting Ji 2021
8.22
[6.81; 9.63]
< 0.001
5.67
2.38
87.94%
Omitting Liu 2023
8.67
[6.98; 10.36]
< 0.001
7.87
2.80
89.28%
Omitting Gao 2025
8.67
[6.98; 10.36]
< 0.001
7.83
2.80
89.29%
Omitting Wang 2024
8.72
[7.06; 10.39]
< 0.001
7.63
2.76
89.21%
Omitting Deng 2022
8.67
[6.97; 10.36]
< 0.001
7.91
2.81
89.27%
Omitting Zhu 2024
8.58
[6.89; 10.27]
< 0.001
7.85
2.80
89.27%
Random effects model
8.60
[7.03; 10.17]
< 0.001
7.26
2.69
88.54%
−10
−5
0
5
10
15
Favours [control]
Favours [experimental]

5C


All study
After removing outliers
Study
MD [95% CI]
Li 2022
Dang 2023
Zhou 2022
Zhang 2024
Yan 2025
Hou 2025
Yu 2023
Yue 2025
Li 2024
Wan 2025
Ji 2021
Liu 2023
Gao 2025
Wang 2024
Deng 2022
Zhu 2024
Random-Effects Model
Mean Difference

19

Figure 5A. Forest plot illustrating the effects of acupuncture in conjunction with rTMS compared to rTMS alone on FMA-UE. **Figure 5B.** Sensitivity analysis indicates that the heterogeneity measures decreased significantly after excluding studies [29,35]. **Figure 5C.** Sensitivity analysis after excluding outlier studies: the pooled results from the remaining 14 studies remain statistically significant.

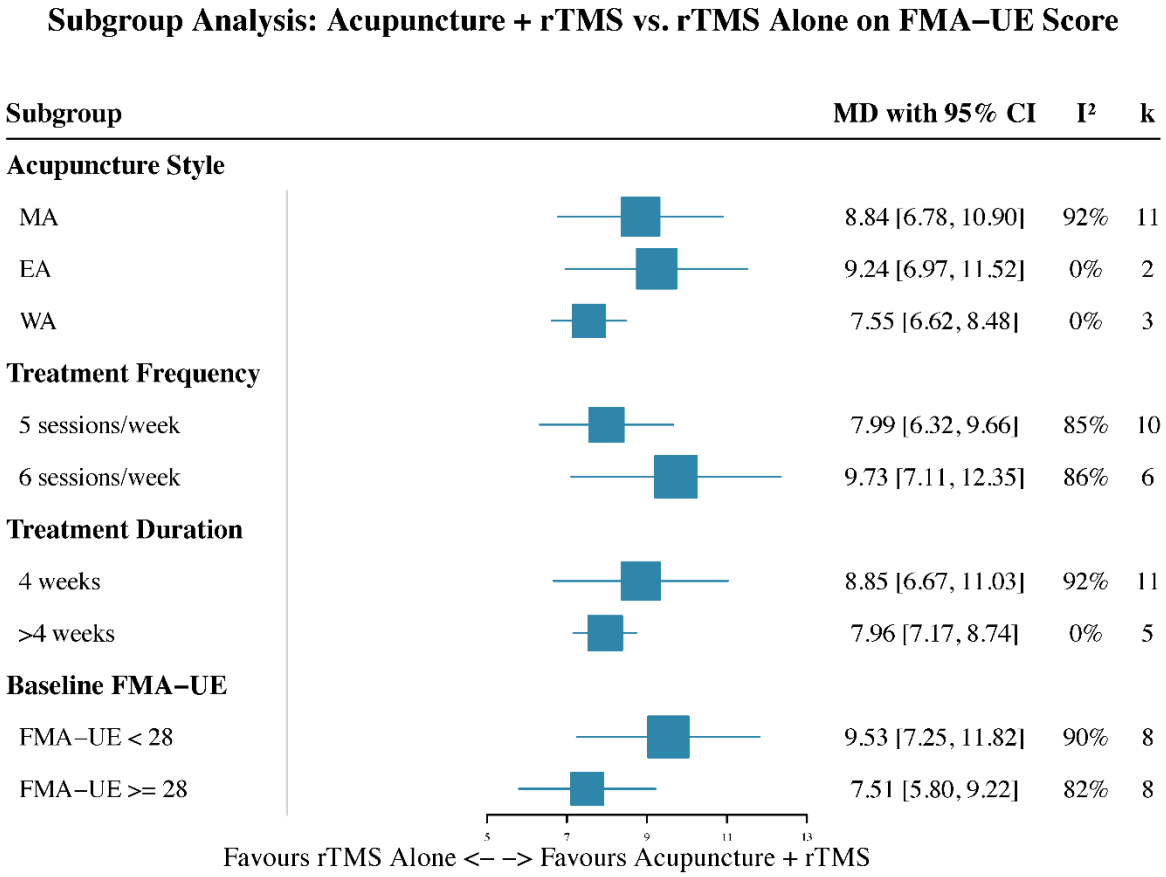


Figure 6. Subgroup analyses for FMA-UE by acupuncture technique, treatment frequency, duration, and baseline severity.

FMA-LE

Fourteen trials [21,22,23,26,29,30,34,35,36,37,41,42,43,45] reported the FMA-LE as an outcome measure. 1,489 patients were involved, with 745 in the combination group and 744 in the rTMS control group. Initial study revealed that combined acupuncture therapy was associated with s

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ignificantly greater improvement in FMA-LE scores in stroke patients relative to rTMS alone (M D 5.06, 95% CI [4.42–5.71], $P < 0.001$, $I^2 = 71.28\%$) (Figure 7A). Sensitivity analysis identified n o significant outlier studies, indicating robust stability of the combined effect size (Figure 7B).

To explore the heterogeneity, we performed subgroup analyses by acupuncture technique, tr eatment frequency, and treatment duration. Manual acupuncture (MA; 6 studies) gave (MD = 4.5 3, 95% CI [3.53, 5.53], $I^2 = 83.2\%$), whereas warm acupuncture (WA; 3 studies) gave (MD = 6.1 0, 95% CI [5.49, 6.72], $I^2 = 15.5\%$). By treatment frequency, 5 sessions/week (5 studies) showed (MD = 4.69, 95% CI [3.34, 6.03], $I^2 = 87.4\%$), 6 sessions/week (3 studies) showed (MD = 5.61, 9 5% CI [4.70, 6.52], $I^2 = 30.2\%$), and one study with 7 sessions/week gave (MD = 5.04, 95% CI [3. 18, 6.90]). For treatment duration, 4-week regimens (5 studies) yielded (MD = 4.54, 95% CI [3.3 9, 5.69], $I^2 = 85.8\%$), while >4 weeks (4 studies) yielded (MD = 5.57, 95% CI [4.51, 6.63], $I^2 = 5$ 7.1%). All subgroups showed statistically significant benefit of the combination therapy (Figure 8).

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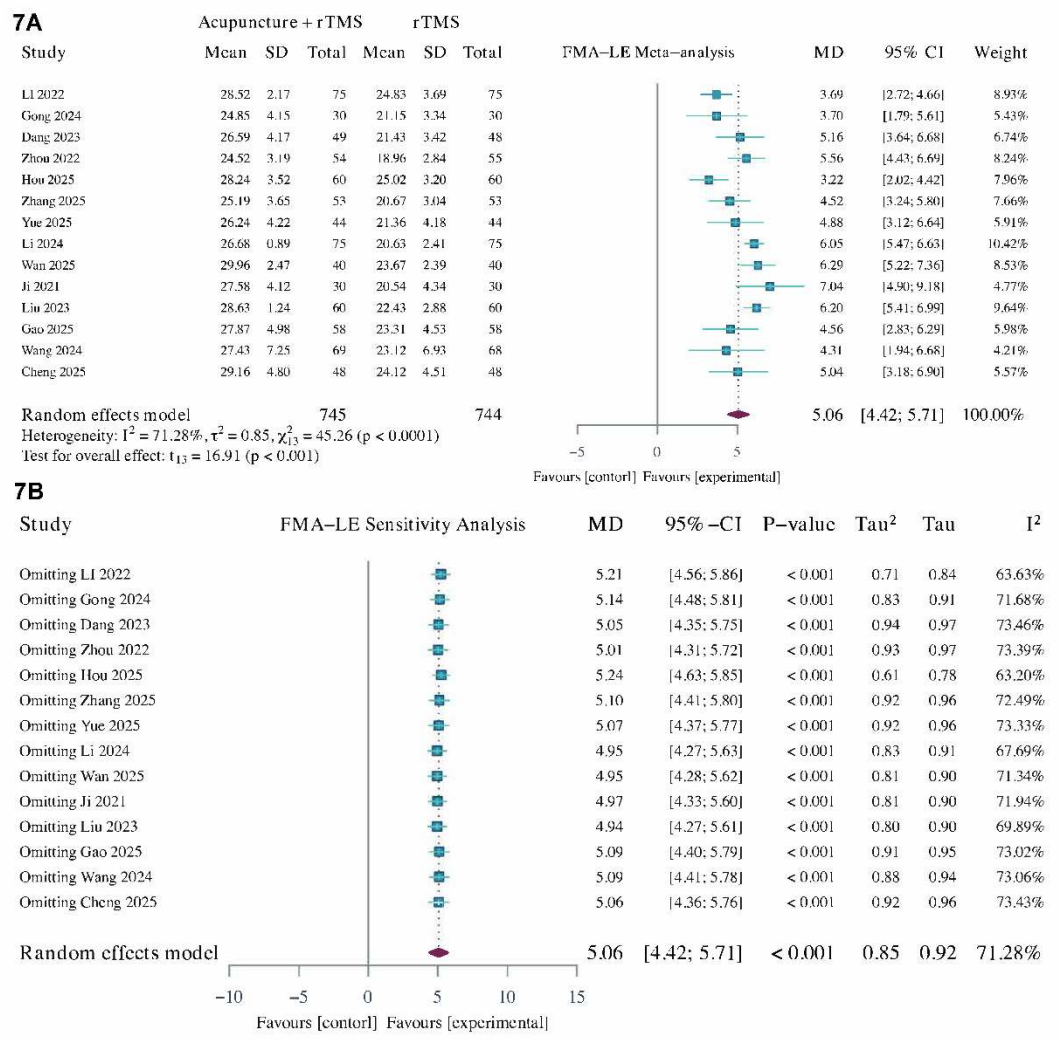


Figure 7A. Forest plot illustrating the effects of acupuncture in conjunction with rTMS compared to rTMS alone on FMA-LE. **Figure 7B**. Sensitivity analysis revealed no significant reduction in the heterogeneity index following sequential exclusion of studies.

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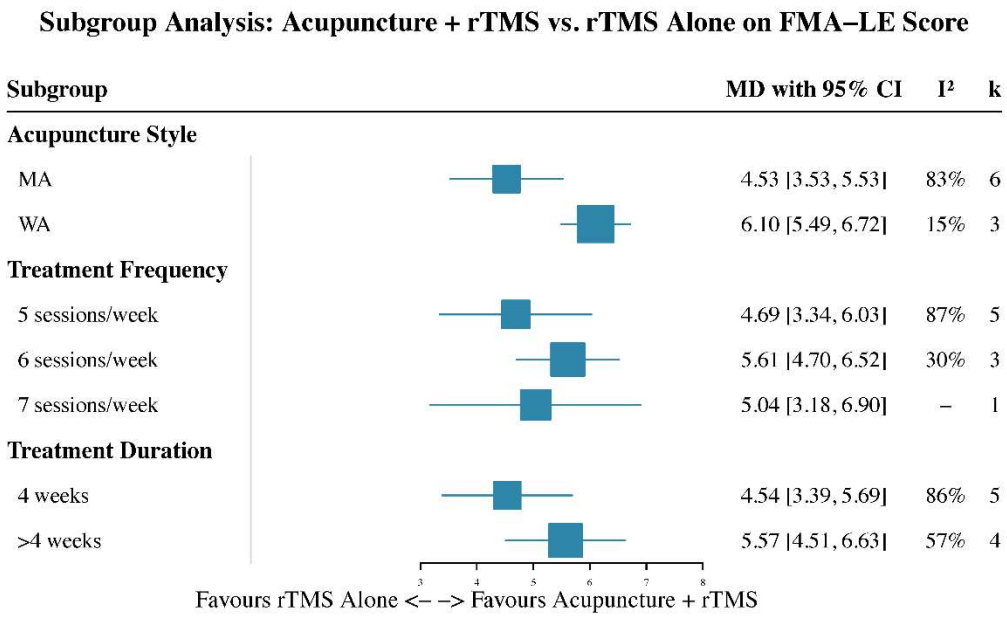


Figure 8. Subgroup analyses for FMA-LE by acupuncture technique, treatment frequency, and treatment duration.

BI

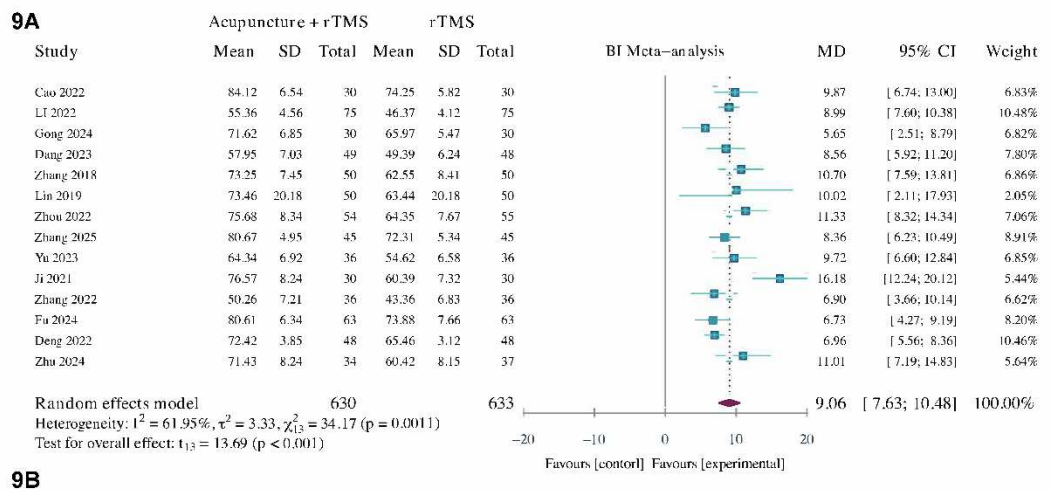
Fourteen trials [19,21,22,23,24,25,26,30,32,37,38,46,47,48] reported BI as an outcome measure. 1,263 patients were enrolled, comprising 630 in the combination group and 633 in the rTMS control group. Initial study revealed that combined acupuncture therapy was associated with significantly greater improvement in BI scores in stroke patients compared to rTMS alone (MD 9.06, 95% CI [7.63–10.48], $P < 0.001$) (Figure 9A), with moderate heterogeneity between studies ($I^2 = 61.95\%$). Systematic outlier and influence analysis identified one study [37] as the primary source of heterogeneity; its exclusion substantially reduced heterogeneity metrics (I^2 and τ^2), which was confirmed by leave-one-out analysis (Figure 9B). In a sensitivity analysis excluding the outlier studies, the pooled effect size from the remaining 13 studies remained statistically significant (MD = 8.54, 95% CI [7.61–9.47], $P < 0.0001$), with markedly reduced inter-study heterogeneity ($I^2 = 38.56\%$). This sensitivity analysis indicates that the observed heterogeneity did not affect the direction or magnitude of the pooled estimate, supporting the robustness of the conclusion (Figure 9C).

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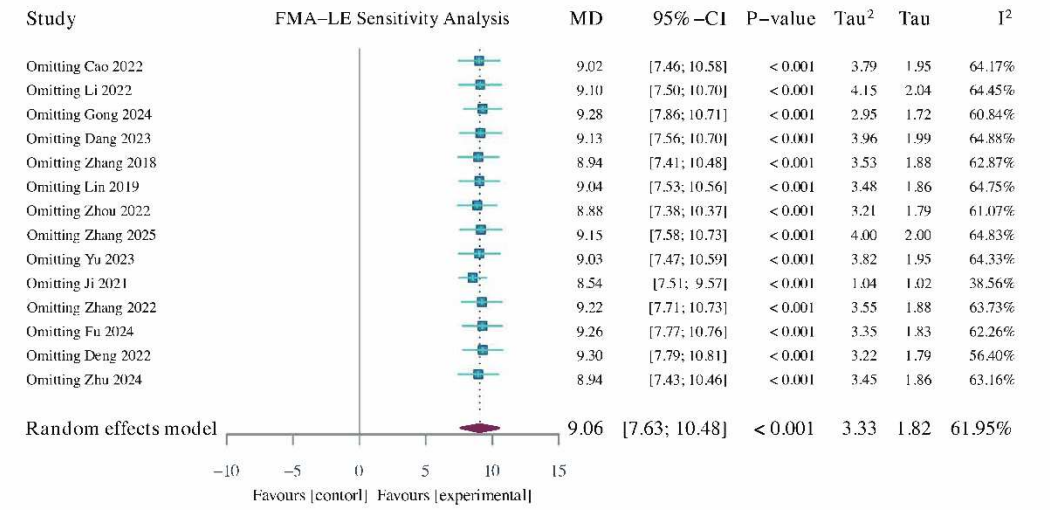
To explore the remaining heterogeneity, we performed subgroup analyses by treatment frequency, treatment duration, and baseline dependency. By treatment frequency, 5 sessions/week (7 studies) gave (MD = 9.34, 95% CI [6.91, 11.77], I^2 = 79.4%), 6 sessions/week (4 studies) gave (MD = 8.66, 95% CI [6.91, 10.41], I^2 = 29.3%), and single studies with 3, 4, or 7 sessions/week gave MDs of 8.36, 9.87, and 10.02, respectively. For treatment duration, 4-week regimens (10 studies) yielded (MD = 8.84, 95% CI [7.42, 10.26], I^2 = 62.5%), while >4 weeks (4 studies) yielded (MD = 9.64, 95% CI [6.94, 12.33], I^2 = 64.1%). When stratified by baseline dependency, patients with severe dependency (BI <40; 6 studies) had (MD = 10.63, 95% CI [8.00, 13.25], I^2 = 79.7%), whereas those with moderate dependency (BI ⩾40; 8 studies) had (MD = 8.32, 95% CI [7.41, 9.22], I^2 = 19.8%). All subgroups favoured the combination therapy, with numerically larger point estimates in the severe-dependency group. (Figure 10)

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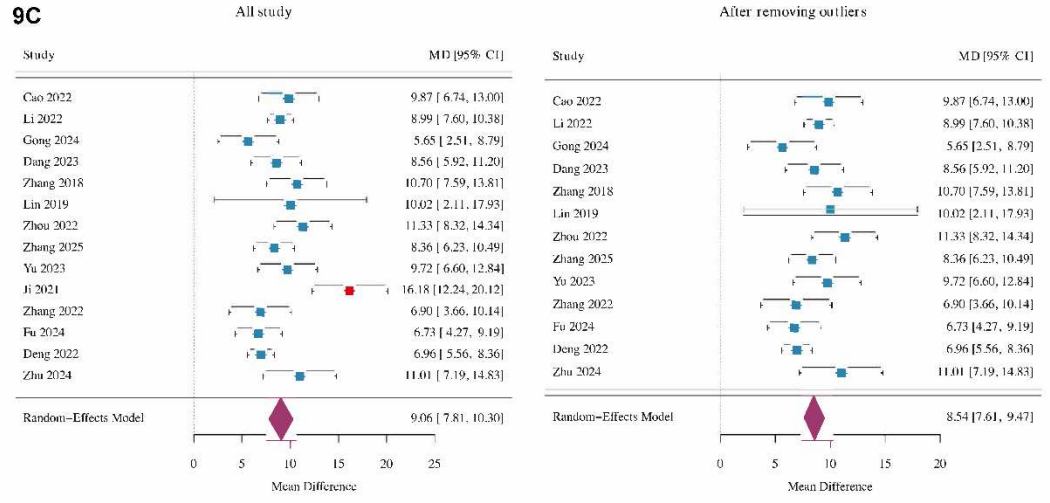
9A


Acupuncture + rTMS
rTMS
Study
Mean SD Total Mean SD Total
BI Meta−analysis
MD 95% CI Weight
Cao 2022 84.12 6.54 30 74.25 5.82 30 9.87 [6.74; 13.00] 6.83%
LI 2022 55.36 4.56 75 46.37 4.12 75 8.99 [7.60; 10.38] 10.48%
Gong 2024 71.62 6.85 30 65.97 5.47 30 5.65 [2.51; 8.79] 6.82%
Dang 2023 57.95 7.03 49 49.39 6.24 48 8.56 [5.92; 11.20] 7.80%
Zhang 2018 73.25 7.45 50 62.55 8.41 50 10.70 [7.59; 13.81] 6.86%
Lin 2019 73.46 20.18 50 63.44 20.18 50 10.02 [2.11; 17.93] 2.05%
Zhou 2022 75.68 8.34 54 64.35 7.67 55 11.33 [8.32; 14.34] 7.06%
Zhang 2025 80.67 4.95 45 72.31 5.34 45 8.36 [6.23; 10.49] 8.91%
Yu 2023 64.34 6.92 36 54.62 6.58 36 9.72 [6.60; 12.84] 6.85%
Ji 2021 76.57 8.24 30 60.39 7.32 30 16.18 [12.24; 20.12] 5.44%
Zhang 2022 50.26 7.21 36 43.36 6.83 36 6.90 [3.66; 10.14] 6.62%
Fu 2024 80.61 6.34 63 73.88 7.66 63 6.73 [4.27; 9.19] 8.20%
Deng 2022 72.42 3.85 48 65.46 3.12 48 6.96 [5.56; 8.36] 10.46%
Zhu 2024 71.43 8.24 34 60.42 8.15 37 11.01 [7.19; 14.83] 5.64%
Random effects model 630 633 9.06 [7.63; 10.48] 100.00%
Heterogeneity: I^2 = 61.95%, τ^2 = 3.33, χ^2_{13} = 34.17 (p = 0.0011)
Test for overall effect: t_{13} = 13.69 (p < 0.001)
−20 −10 0 10 20
Favours [control] Favours [experimental]

9B


Study
FMA−LE Sensitivity Analysis
MD 95%−CI P−value Tau² Tau I²
Omitting Cao 2022 9.02 [7.46; 10.58] < 0.001 3.79 1.95 64.17%
Omitting Li 2022 9.10 [7.50; 10.70] < 0.001 4.15 2.04 64.45%
Omitting Gong 2024 9.28 [7.86; 10.71] < 0.001 2.95 1.72 60.84%
Omitting Dang 2023 9.13 [7.56; 10.70] < 0.001 3.96 1.99 64.88%
Omitting Zhang 2018 8.94 [7.41; 10.48] < 0.001 3.53 1.88 62.87%
Omitting Lin 2019 9.04 [7.53; 10.56] < 0.001 3.48 1.86 64.75%
Omitting Zhou 2022 8.88 [7.38; 10.37] < 0.001 3.21 1.79 61.07%
Omitting Zhang 2025 9.15 [7.58; 10.73] < 0.001 4.00 2.00 64.83%
Omitting Yu 2023 9.03 [7.47; 10.59] < 0.001 3.82 1.95 64.33%
Omitting Ji 2021 8.54 [7.51; 9.57] < 0.001 1.04 1.02 38.56%
Omitting Zhang 2022 9.22 [7.71; 10.73] < 0.001 3.55 1.88 63.73%
Omitting Fu 2024 9.26 [7.77; 10.76] < 0.001 3.35 1.83 62.26%
Omitting Deng 2022 9.30 [7.79; 10.81] < 0.001 3.22 1.79 56.40%
Omitting Zhu 2024 8.94 [7.43; 10.46] < 0.001 3.45 1.86 63.16%
Random effects model 9.06 [7.63; 10.48] < 0.001 3.33 1.82 61.95%
−10 −5 0 5 10 15
Favours [control] Favours [experimental]

9C


All study
Study
MD [95% CI]
Cao 2022 9.87 [6.74, 13.00]
Li 2022 8.99 [7.60, 10.38]
Gong 2024 5.65 [2.51, 8.79]
Dang 2023 8.56 [5.92, 11.20]
Zhang 2018 10.70 [7.59, 13.81]
Lin 2019 10.02 [2.11, 17.93]
Zhou 2022 11.33 [8.32, 14.34]
Zhang 2025 8.36 [6.23, 10.49]
Yu 2023 9.72 [6.60, 12.84]
Ji 2021 16.18 [12.24, 20.12]
Zhang 2022 6.90 [3.66, 10.14]
Fu 2024 6.73 [4.27, 9.19]
Deng 2022 6.96 [5.56, 8.36]
Zhu 2024 11.01 [7.19, 14.83]
Random−Effects Model 9.06 [7.81, 10.30]
0 5 10 15 20 25
Mean Difference
After removing outliers
Study
MD [95% CI]
Cao 2022 9.87 [6.74, 13.00]
Li 2022 8.99 [7.60, 10.38]
Gong 2024 5.65 [2.51, 8.79]
Dang 2023 8.56 [5.92, 11.20]
Zhang 2018 10.70 [7.59, 13.81]
Lin 2019 10.02 [2.11, 17.93]
Zhou 2022 11.33 [8.32, 14.34]
Zhang 2025 8.36 [6.23, 10.49]
Yu 2023 9.72 [6.60, 12.84]
Zhang 2022 6.90 [3.66, 10.14]
Fu 2024 6.73 [4.27, 9.19]
Deng 2022 6.96 [5.56, 8.36]
Zhu 2024 11.01 [7.19, 14.83]
Random−Effects Model 8.54 [7.61, 9.47]
0 5 10 15 20
Mean Difference

25

Figure 9A. Forest plot illustrating the effects of acupuncture in conjunction with rTMS compared to rTMS alone on BI. **Figure 9B**. Sensitivity analysis indicates that the heterogeneity measure decreased significantly after excluding study [37]. **Figure 9C**. Sensitivity analysis after excluding outlier studies; the pooled results from the remaining 13 studies remain statistically significant.

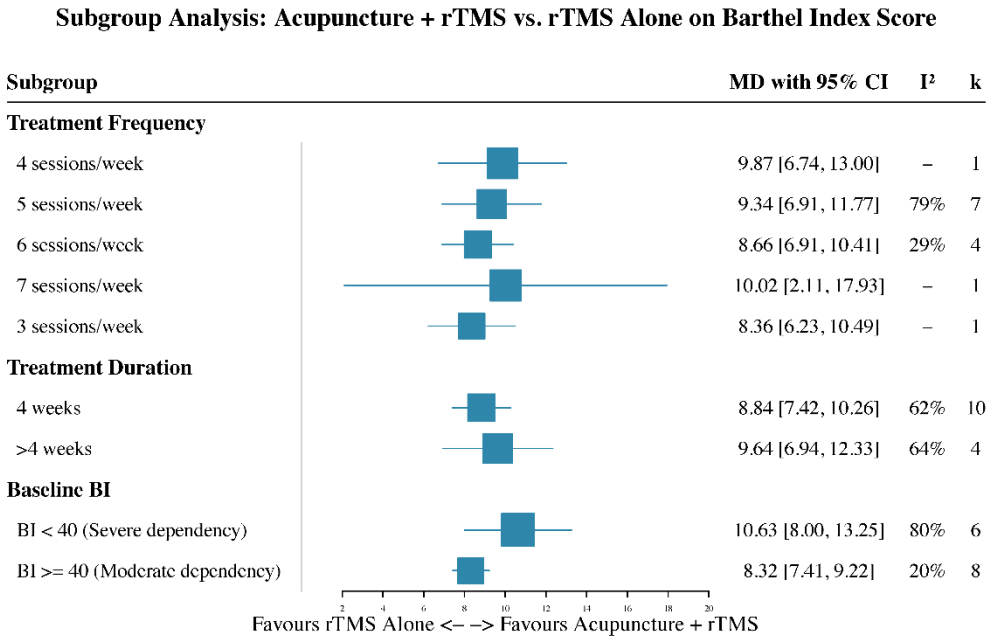


Figure 10. Subgroup analyses for the Barthel Index by treatment frequency, treatment duration, and baseline dependency.

Curative ratio

Sixteen trials [21,23,25,27,28,32,34,37,39,40,41,42,43,44,45,47] reported the curative ratio a s an outcome measure. A total of 1,538 patients participated, with 770 in the combined group and 768 in the rTMS control group. Pooled meta-analysis data revealed a relative risk for cure rate of 1.20 (RR = 1.20, 95% CI = 1.15–1.26). No substantial heterogeneity was detected among the gro ups ($Chi^2 = 6.28$, P = 0.9746, $I^2 = 0\%$). (Figure 11)

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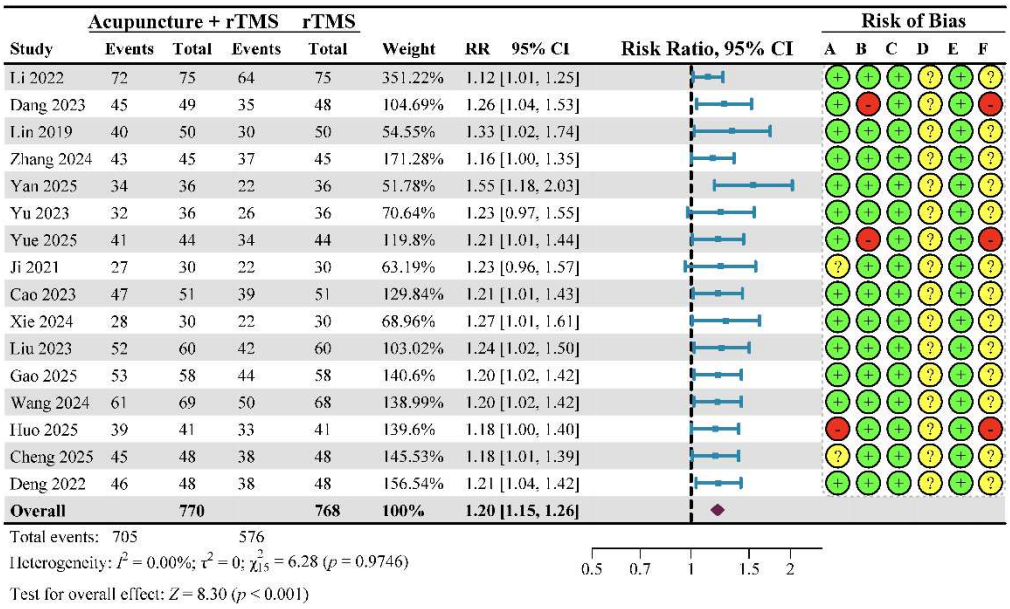


Figure 11. Forest plot and risk of bias assessment for the curative ratio.

Publication bias

Funnel plots were analysed using a fixed-effects model, incorporating assessments from multiple studies (n > 10). The overall article quality for FMA-UE, FMA-LE, BI, and the Curative ratio was moderate. The results exhibited remarkable symmetry in the funnel plots for FMA-UE, FMA-LE, BI, and the Curative ratio, signifying the absence of substantial publication bias. (Figure 12)

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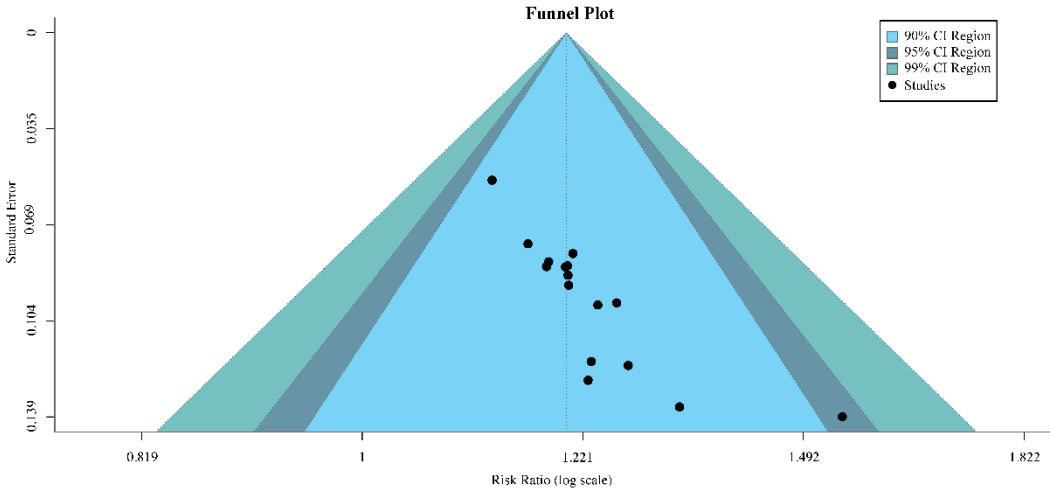


Figure 12. Funnel plot for publication bias detection.

Discussion

This systematic review and meta-analysis synthesised 30 RCTs to evaluate the efficacy and s afety of acupuncture combined with rTMS versus rTMS alone for post-stroke motor dysfunction. The pooled analysis demonstrated that combination therapy was associated with statistically signi ficant and clinically meaningful improvements across multiple outcomes, including FMA-Total (MD = 7.11), FMA-UE (MD = 8.60), FMA-LE (MD = 5.06), Barthel Index (MD = 9.06), and ove rall efficacy (RR = 1.20). For the highly heterogeneous initial outcomes of FMA-UE and BI, syst ematic sensitivity analyses were performed to identify potential outlier studies. After excluding th ese studies, the pooled effect estimates remained statistically significant and showed markedly red uced heterogeneity (FMA-UE: MD = 8.21, I^2 = 0%; BI: MD = 8.54, I^2 = 38.56%). These sensitivi ty analyses confirm that the observed heterogeneity does not undermine the overall conclusions a nd that the treatment effects are robust. Collectively, these results indicate that adding acupunctur e to rTMS reliably enhances upper limb motor function and activities of daily living, with consist ent benefits also observed for lower limb recovery. However, it should be noted that only seven st udies reported the FMA-Total score, which limits the generalisability of our conclusion on global motor impairment, as most trials focused separately on upper or lower extremity outcomes.

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Our subgroup analyses provide exploratory insights into how patient and intervention characteristics might influence treatment response. For upper-limb recovery, the absence of heterogeneity in the warm acupuncture and electroacupuncture subgroups suggests that standardised non-manual techniques may yield more consistent benefits than traditional manual acupuncture, although the small number of studies limits firm conclusions. The larger effect size observed with six versus five weekly sessions hints at a possible dose-response relationship, while the numerically greater gain in patients with severe baseline impairment (FMA-UE <28) supports the hypothesis that those with greater motor deficits have more room for improvement. Similar patterns emerged for lower-limb recovery: warm acupuncture produced a larger and more homogeneous effect than manual acupuncture, possibly because its thermal and proprioceptive input is particularly advantageous for lower-limb muscle activation. Treatment courses longer than four weeks also conferred numerically larger and more consistent benefits, suggesting that sustained neuroplastic changes require adequate time. For daily living activities, patients with severe baseline dependency (BI <40) showed a greater absolute gain, echoing the upper-limb finding that more disabled individuals may derive larger benefits from the combined intervention. Collectively, these hypothesis-generating observations suggest that warm acupuncture, higher treatment frequency (six sessions/week), and longer duration (>4 weeks) may optimise outcomes, particularly in patients with severe baseline impairment. However, given the small number of studies in several subgroups and the risk of false-positive findings, these results should be interpreted as exploratory and require confirmation in dedicated prospective trials.

Our results mostly corroborate the conclusions of Yan et al.'s comprehensive review [49], affirming that the combination of acupuncture and rTMS offers a distinct benefit over rTMS alone in enhancing FMA-UE scores and daily living activities in stroke patients. However, our study provides essential supplementary and in-depth insights into the existing evidence through more thorough analytical methods and a comprehensive assessment. In Yan et al.'s research, the analysis of FMA-UE faced extremely high heterogeneity ($I^2 > 97\%$). Although this was speculated to be related to differences in intervention details and individual studies, no statistical sensitivity analysis was conducted to verify this. In contrast, our systematic sensitivity analysis successfully identified and excluded specific outlier studies responsible for FMA-UE heterogeneity. This rendered the pooled effect size estimation more robust and eliminated heterogeneity. Secondly, whilst Yan et al.'s study focused on the upper limbs, our analysis further revealed that combined therapy yields clin

ically significant improvements for FMA-LE. Moreover, our subgroup analyses identified warm acupuncture, higher treatment frequency (six sessions/week), and longer treatment duration (>4 weeks) as potential modifiers of treatment response, particularly for upper- and lower-limb recovery. Patients with severe baseline impairment (FMA-UE <28 or BI <40) also appeared to derive larger absolute gains.

In terms of clinical practice and applied value, this study provides high-level evidence supporting the integration of acupuncture into rTMS-based stroke rehabilitation programmes. The combined therapy resulted in improvements of approximately 8.2 points on the FMA-UE and nearly 8.5 points on the BI, both of which reached clinically significant thresholds. Moreover, the combined approach demonstrated favourable safety profiles, with only a minority of participants reporting mild and tolerable adverse events (e.g., fever, needle insertion site pain) during the study, and no patient withdrawals occurred. Given the relative affordability and accessibility of acupuncture techniques, combined with the robust treatment effects observed, position this combination strategy as a highly cost-effective approach to augment standard rTMS-based rehabilitation. This is particularly relevant for optimizing resource allocation in healthcare systems with limited infrastructure.

Notwithstanding these positive findings, our study has several limitations. First, implementing blinding—a significant challenge in non-pharmacological trials—was often inadequate. Due to the unique nature of acupuncture procedures, blinding patients and practitioners proves exceptionally challenging. In this study, most investigations failed to blind outcome assessors, potentially introducing measurement bias into subjective assessment tools, such as the FMA, which could lead to overestimating efficacy. Additionally, the control interventions varied across studies: some used rTMS alone, while others used rTMS plus sham acupuncture. Although sham acupuncture was intended to blind patients, the lack of consistent blinding procedures and the inherent difficulty of sham needling represent an important source of methodological heterogeneity that was not fully addressed. Secondly, randomisation processes in some studies were flawed; for instance, merely stating ‘randomised’ without detailing specific methods, or even employing non-standard randomisation by treatment group in two studies, increased the risk of selection bias. Moreover, unavoidable heterogeneity existed in intervention measures, such as acupuncture techniques, needle insertion depth, and deqi sensation. Our subgroup analyses attempted to account for some of this variabi

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lity, but the small number of studies within certain subgroups limits the precision of subgroup esti mates and precludes robust interaction testing. Additionally, the exploratory nature of these subgr oup analyses means that false-positive findings cannot be excluded; therefore, all subgroup result s should be interpreted as hypothesis-generating and require prospective confirmation. Furthermo re, although funnel plot symmetry was acceptable for some indicators, the near-universal reportin g of positive results across all included studies strongly suggests potential publication bias of neg ative findings. This may have led to an overestimation of the actual effect size in this meta-analys is.

Based on the above findings, we propose the following recommendations for future research. First, large-scale, multicentre randomised controlled trials with factorial designs or stratified rand omisation are needed to confirm whether warm acupuncture, higher-frequency sessions, or longer treatment durations indeed confer superior benefit, and to validate the observed tendency that pat ients with severe baseline impairment derive larger absolute gains. Second, researchers should ad here to reporting standards such as STRICTA, drawing upon this study's findings regarding mains tream techniques, high-frequency acupoints, and standard treatment durations to establish more re producible intervention frameworks. Third, incorporating objective biological markers, such as ki nematics, transcranial magnetic stimulation-evoked potentials, or functional neuroimaging, may c ompensate for the limitations of subjective scales and provide deeper insights into the neural mec hanisms underlying this combined therapy. Fourth, future trials should rigorously implement blin ding of outcome assessors and, where possible, employ sham acupuncture controls to minimise p erformance and detection bias.

Conclusion

In summary, acupuncture combined with rTMS is an effective and safe intervention that enh ances motor function recovery in patients with hemiplegia after IS. Through in-depth heterogeneit y analysis and patient stratification, this study has preliminarily identified the patient groups that most clearly benefit from this approach—namely, those with upper limb dysfunction. This offers a promising and targeted strategy for alleviating the global burden of disability following IS. Futu re research should prioritize the design of rigorous, larger-scale, double-blind trials employing sta ndardised acupuncture protocols to validate further and optimise this combined intervention.

Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

Geng Li: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft. Mengqi Yue: Investigation, Writing - original draft, Validation. Shuochen Fan: Data curation. Qichen Bai: Data curation. Shuai Li: Data curation. Xiaolin Yang: Visualization. Xu Chen: Software, Resources. Yihao Zhou: Project administration. Jing zhong: Supervision. Jing Shi: Funding acquisition, Writing - review & editing. All authors read and approved the final manuscript.

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Declaration of generative AI use

The author declares that no general artificial intelligence technology was employed in the creation of this manuscript.

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