

뇌졸중 환자의 호흡기능에 대한 도인운동요법의 효과: 체계적 고찰 및 메타분석

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Effects of Dao-yin Exercise Therapy on Respiratory Function in Patients with Stroke: A Systematic Review and Meta-analysis

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방법 2025년 3월까지 주요 데이터베이스를 검색하여 뇌졸중 환자를 대상으로 도인 운동치료와 대조군을 비교한 무작위 대조시험을 선정하였다. 주요 평가지표는 호흡근 근력과 폐기능 지표였으며, 이차 평가지표는 균형기능, 운동기능 및 일상생활활동 수행능력이었다. 메타분석은 고정 또는 랜덤 효과모형을 사용하였다.

결과 총 7편의 연구(574명)가 포함되었다. 대부분의 포함 연구에서 도인 운동치료는 복합중재의 일부로 시행되었다. 도인 운동치료는 최대 호기압, 최대 발성시간, 균형기능 및 일상생활활동 수행능력을 유의하게 향상시켰다. 반면 최대 흡기압, 노력성 폐활량, 1초간 노력성 호기량, 최대 호기유속 및 횡격막 가동성에서는 유의한 차이가 없었다.

결론 도인 운동치료는 뇌졸중 환자의 호기근 근력, 발성 조절, 균형기능 및 기능적 독립성 향상에 도움이 될 수 있다. 그러나 흡기기능과 폐용량에 대한 효과는 명확하지 않아 표준화된 중재 프로토콜을 적용한 추가 연구가 필요하다. (J Korean Med Rehabil 2026;36(3):15-33)

Key words Stroke, Respiratory function tests, Dao-yin exercise therapy, Systematic review, Meta-analysis

Introduction»»»

Stroke represents a major global health burden owing to its high mortality, substantial disability rates, and persistent long-term complications¹⁻³. Stroke is classified as ischemic or hemorrhagic and progresses through acute, subacute, and chronic phases^{2,4}. During the acute stage, interruption of cerebral blood flow leads to neuronal injury, manifesting as motor, sensory, and cognitive impairments⁵. The subacute and chronic phases focus on functional rehabilitation to restore lost function and improve quality of life⁶. However, despite advances in rehabilitation, stroke-related complications often persist, substantially impeding functional recovery^{2,3}.

Respiratory dysfunction is a common yet underrecognized complication following stroke⁷. Neurological damage disrupts both automatic and voluntary respiratory control, resulting in irregular breathing patterns, respiratory muscle weakness, and reduced pulmonary capacity⁸. Stroke-induced neuromuscular impairment affects key respiratory muscles, including the diaphragm, impairing ventilatory efficiency⁹. Additionally, dysphagia and compromised airway protective mechanisms significantly increase the risk of aspiration pneumonia¹⁰. Hemiplegia and abnormal muscle tone further limit thoracic mobility, thereby compromising respiratory mechanics. Given the substantial impact of respiratory dysfunction on post-stroke recovery outcomes, targeted rehabilitative interventions aimed at improving pulmonary function are warranted.

Dao-yin exercise therapy, a movement-based intervention rooted in traditional Chinese medicine (TCM), has been increasingly investigated as a rehabilitative approach for stroke. This therapeutic intervention encompasses structured movement and controlled breathing exercises, including Tai Chi, Baduanjin, Liu Zi Jue, and Qigong, which improve neuromuscular coordination, strengthen respiratory muscles, and enhance peripheral circulation^{11,12}. In Korean traditional medicine, Dao-yin techniques are applied with an emphasis on muscle

strengthening, postural correction, and range-of-motion exercise to restore neuromuscular function in patients with central paralysis¹³⁻¹⁶. While some studies have demonstrated cardiopulmonary benefits of Dao-yin¹⁷, evidence specifically addressing respiratory outcomes in post-stroke populations remains limited, largely owing to methodological limitations such as inadequate blinding and unclear randomization procedures. Therefore, we conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to evaluate Dao-yin exercise therapy on respiratory function in patients with stroke, to inform clinical practice and guide the development of evidence-based rehabilitation strategies.

Materials and Methods»»»

This systematic review and meta-analysis was conducted in accordance with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) 2020 guidelines¹⁸. The study protocol was registered in the International Prospective Register of Systematic Reviews (registration No.: CRD420251009728) in February 2025.

1. Search strategy

International and domestic databases were comprehensively searched to identify RCTs examining the effects of Dao-yin exercise therapy, including TCM-based exercise therapies (TCMET), Tai Chi, Qigong, Baduanjin, Liu Zi Jue, and Wu Qin Xi, on the respiratory outcomes of patients with stroke. The international sources consulted included PubMed, Embase, the Cochrane Library, and the China National Knowledge Infrastructure (CNKI), whereas Korean literature was identified through the Research Information Sharing Service, Database Periodical Information Academic, National Digital Science Library, and Korean studies Information Service System. The search queries employed a combination of medical sub-

ject heading (MeSH) descriptors and free-text terms to optimize sensitivity and specificity. Key terms included variations of TCMET interventions (e.g., “Tai Chi,” “Qigong,” “Baduanjin,” and “Dao-yin”) combined with terms related to stroke (e.g., “stroke,” “cerebrovascular accident,” “post-stroke rehabilitation”). Filters were used to ensure that only RCTs were included. Studies were included regardless of publication year, geographical location, or language, allowing for the capture of studies from diverse time periods and geographic regions. The search queries used for each database are presented in Appendix I-IV. In addition, Google Scholar was manually searched on March 26, 2025, using key terms similar to those employed in the database searches to broaden the scope by identifying studies that might not appear in commonly used databases.

2. Inclusion criteria

Studies were included if they involved participants with a confirmed diagnosis of stroke, encompassing both the ischemic and hemorrhagic types, regardless of the chronicity of the disease. The interventions were based on Dao-yin exercise therapies, including but not limited to Tai Chi, Qigong, Baduanjin, Liu Zi Jue, and Wu Qin Xi. These interventions can be delivered either as stand-alone treatments or in conjunction with conventional rehabilitation programs. Eligible studies included control groups that received no treatment, sham interventions, standard care, or alternative therapeutic approaches. Respiratory function was assessed as either a primary or secondary outcome, utilizing objective parameters such as forced vital capacity (FVC), forced expiratory volume in one second (FEV₁), maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), or other standardized indicators of pulmonary function. Only RCTs were included.

3. Exclusion criteria

Studies were excluded if they involved participants without a confirmed stroke diagnosis or if they focused primarily on other neurological or respiratory conditions unrelated to stroke. Interventions that did not incorporate Dao-yin-based practices were excluded. Furthermore, studies lacking a comparator group or employing non-comparative designs (e.g., single-arm trials) were not eligible for inclusion. Studies that did not report respiratory-related outcomes or that provided insufficient data for the meta-analysis were excluded. In terms of study design, non-randomized studies, including observational designs (e.g., cohort or case-control studies), case reports, narrative reviews, systematic reviews, meta-analyses, conference abstracts, editorials, and expert commentaries were excluded. Finally, non-peer-reviewed sources such as preprints, unpublished theses, and other forms of gray literature were not considered for inclusion.

4. Selecting articles

Two independent reviewers (SY and WCS) initially screened the titles and abstracts of the retrieved articles by applying the predefined inclusion and exclusion criteria. Duplicate studies were first removed using Endnote 21.5 reference management software. The study selection process was performed using Microsoft 365 Excel, and the results were organized and tracked throughout the screening process. Disagreements were resolved by discussion and consensus between the two reviewers and the corresponding author (HK). The full texts of the remaining studies were independently reviewed by both the researchers to ensure alignment with the inclusion criteria. Studies that did not meet the inclusion criteria, including those unrelated to the research topic or those that lacked critical information, were excluded. The final list of the included studies was determined after careful evaluation and consensus.

5. Risk of bias assessment

Two independent reviewers used the Cochrane risk of bias (RoB) 1.0 tool to assess bias in each RCT included in this review, based on the methodology described in the Cochrane Handbook for systematic reviews of interventions¹⁹⁾. The assessment covered seven domains of potential bias: 1) random sequence generation; 2) allocation concealment; 3) blinding of participants and personnel; 4) blinding of outcome assessment; 5) incomplete outcome data; 6) selective reporting; and 7) other sources of bias. Discrepancies or disagreements were discussed with the corresponding author until a consensus was reached. This process ensured that the RoB assessment was comprehensive, consistent, and conducted with the highest degree of methodological rigor, thereby strengthening the validity of the review findings.

6. Data synthesis and analysis

RevMan 5.4 (Cochrane Collaboration), a standard software recommended for systematic reviews and meta-analyses, was used for meta-analysis. To enhance clarity and readability, the scales of the forest plots generated using RevMan 5.4 were adjusted arbitrarily during figure generation. This adjustment aimed to improve the visibility of the individual study effects and the overall pooled effect size. Continuous data were analyzed using the mean difference (MD) when outcome measures were reported in the same unit across studies. When studies reported outcomes in different units (e.g., FVC in L vs. % predicted), a standardized mean difference (SMD) was applied to ensure comparability. Risk ratios were calculated for binary outcomes and all estimates were reported with 95% confidence intervals (CIs). Considering the variations in treatment duration and control group characteristics across the included studies, clinical heterogeneity was carefully assessed to ensure a robust synthesis of data and yield more generalizable results.

When the outcome data were reported as medians with interquartile ranges, appropriate statistical techniques were applied to estimate the corresponding means and standard deviations. For sample sizes greater than 25, the median was used as an estimate of the mean and the standard deviation (SD) was calculated using the following formula:

$$SD = \frac{IQR}{1.35}$$

For smaller sample sizes, the means and SD were approximated using the method described by Hozo et al.²⁰⁾.

Additionally, when means and 95% CIs were available, the standard deviation was estimated using the following appropriate statistical formula:

$$SD = \sqrt{N} \times \frac{\text{Upper CI} - \text{Lower CI}}{3.92}$$

where N represents the sample size of the respective group.

In cases where studies reported Berg balance scale (BBS) scores on a 56-point scale, the means and standard deviations were converted to a 100-point scale using a simple linear transformation (i.e., multiplying by 100/56) to allow for data pooling using MD. Similarly, when outcomes were reported in both absolute units (L) and percentages of predicted values (%pred), the SMD was used to account for the differences in measurement units. The degree of heterogeneity among the included studies was evaluated using the I^2 statistic, which is a standard measure of the inconsistency between study results. I^2 values were interpreted using conventional thresholds: 0–40% indicated low heterogeneity, 30–60% suggested moderate, 50–90% substantial, and values $\geq 70\%$ reflected a high level of heterogeneity. When the I^2 value was $<50\%$, which suggested low-to-moderate heterogeneity, a fixed-effects model was used for the meta-analysis, assuming that the effect size was consistent across studies. Conversely, for studies exhibiting substantial heterogeneity ($I^2 \geq 50\%$), a random-effects model was employed, ensuring a more generalized estimation of the intervention effect.

Results»»»

1. Study selection

Initial searches across PubMed (n=106), Embase (n=165), Cochrane Library (n=153), and CNKI (n=15) yielded 439 records, with three additional records identified through Google Scholar.

After removing 180 duplicate records, 259 were retained for title and abstract screening. Of these, 191 were excluded because of lack of relevance based on their titles and abstracts.

The full texts of 68 reports from the database searches and three from Google Scholar were retrieved. However, 24 reports were not accessible in the database searches. Consequently, 44 reports from database searches and three records identified via Google Scholar were evaluated for eligibility using predefined inclusion and exclusion criteria.

Following this assessment, nine reports were excluded as non-RCTs and 31 were excluded because of irrelevant

outcomes. Seven studies met the inclusion criteria and were included in the final analysis²¹⁻²⁷. The full study selection process is illustrated in the PRISMA flow diagram (Fig. 1).

2. Study characteristics

Seven RCTs published between 2021 and 2024—all from China—were analyzed, comprising 574 participants (282 men, 172 women, 120 sex unspecified). Mean ages in intervention groups ranged 57.94 ± 9.38 to 69.40 ± 11.09 years; control groups, 58.23 ± 11.81 to 71.20 ± 9.48 years (Table I).

Participants had diverse post-stroke sequelae (dysarthria, trunk postural instability, cardiopulmonary dysfunction) and included both ischemic and hemorrhagic cases, although stroke subtype reporting was inconsistent. Intervention duration varied from 3 weeks to 6 months; most studies adopted 3- to 4-week protocols, with one 6-month study²¹.

Regarding the intervention types, none of the studies evaluated Dao-yin as a standalone therapy. Six studies^{21-23,25-27} investigated Dao-yin combined with conven-

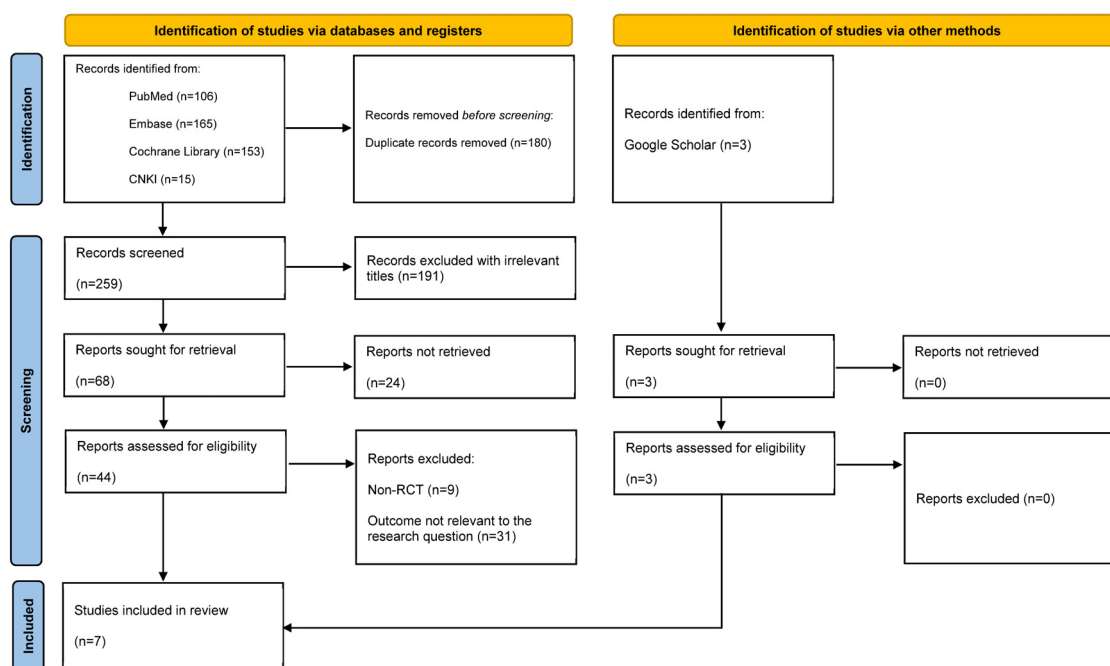


Fig. 1. PRISMA 2020 flow diagram. PRISMA: preferred reporting items for systematic reviews and meta-analyses, CNKI: China National Knowledge Infrastructure, RCT: randomized controlled trial.

Table 1. Characteristics of the Included Studies

Author (year)	Study design	Population	Sample size (I/C)	Sex		Age (y)		Type of stroke		Duration of stroke (w)	
				Male	Female	Intervention	Control	Cerebral infarction	Cerebral hemorrhage	Intervention	Control
Zheng et al. ²³⁾ (2021)	Blind	Subacute phase (≤ 2 months)	30/30	43	17	63.50 $\pm$ 10.36	67.23 $\pm$ 9.15	47	13	26.23 $\pm$ 15.59 d	30.97 $\pm$ 14.19 d
Wang et al. ²⁷⁾ (2021)	Evaluator-blind	a/w dysarthria	48/50	29	69	69.40 $\pm$ 11.09	71.20 $\pm$ 9.48	79	19	73.60 d (57.02~90.19)	76.98 d (60.90~93.06)
Wang et al. ²²⁾ (2022)	Parallel group	Recovery phase	32/31	48	15	65.25 $\pm$ 9.21	60.65 $\pm$ 12.21	50	13	61.31 $\pm$ 43.77 d	72.26 $\pm$ 52.88 d
Liu et al. ²⁴⁾ (2023)	Parallel group	Stroke	60/60	70	50	60.52 $\pm$ 12.22	60.28 $\pm$ 12.37	N	N	8.20 $\pm$ 2.12 d	8.33 $\pm$ 2.20 d
Cui et al. ²⁶⁾ (2023)	Parallel group	Hemiplegic stroke a/w trunk postural control disorder (TIS scale 8-18)	23/20	35	8	66 (60~72)	65.5 (63~71)	41	2	39 d (21~86)	74.50 d (45~128.75)
Xia et al. ²⁵⁾ (2023)	Parallel group	a/w spastic dysarthria	35/35	57	13	57.94 $\pm$ 9.38	58.23 $\pm$ 11.81	57	13	10.63 $\pm$ 1.61 w	9.11 $\pm$ 3.18 w
Zhang et al. ²¹⁾ (2024)	Parallel group	a/w balance+cardiopulmonary impairment	60/60	N	N	N	N	N	N	N	N

I: intervention, C: control, w: weeks, a/w: associated with, d: days, TIS: trunk impairment scale, N: not reported.

tional rehabilitation, while one study²⁴⁾ utilized a highly complex intervention comprising Dao-yin, acupuncture, and conventional rehabilitation.

Methodological heterogeneity was evident. Five studies employed Liu Zi Jue combined with conventional rehabilitation (speech, occupational or respiratory therapy)^{21-23,25,27)}. The remaining studies used “Taking the Waist as the Axis” exercises²⁶⁾ to enhance trunk control or acupuncture plus traditional Chinese medical guidance alongside conventional respiratory²⁴⁾ or core-stability training to comprehensive physiotherapy and occupational/speech therapy, thereby complicating direct between-study comparisons.

Respiratory outcomes included FVC, FEV₁, peak expiratory flow (PEF), MIP, MEP, and ultrasound-derived diaphragmatic indices (thickness, mobility, thickening fraction). In dysarthric populations, maximum phonation time (MPT) was assessed. Functional recovery was evaluated with the BBS²⁸⁾, Fugl-Meyer assessment (FMA)²⁹⁾, trunk impairment scale³⁰⁾, and modified Barthel index (MBI)³¹⁾, while cognition and quality of life were measured with the Montreal cognitive assessment³²⁾ and stroke-specific quality of life scale³³⁾, respectively. Several studies also measured intra-abdominal pressure, abdominal muscle activation, and intervention-related adverse events (Table II).

Table II. Intervention Details and Outcome Measures

Author (year)	Type of intervention		Time/frequency/period	Outcomes/measurements
	Intervention	Control		
Zheng et al. ²³⁾ (2021)	Conventional rehabilitation training+Liu Zi Jue exercise	Conventional rehabilitation training+conventional respiration training	45 min, 5 times/week for 3 weeks	TIS, MIP, MEP, FEV ₁ , FVC, PEF, MMEF, diaphragmatic movement, IAP, BBS, MBI
Wang et al. ²⁷⁾ (2021)	Basic articulation+Liu Zi Jue Qigong	Basic articulation+traditional breathing training	40 min, 5 times/week for 3 weeks	Modified FDA, MPT, maximal counting ability, /s/ [*] , /z/ [†] , s/z ratio [‡] , loudness
Wang et al. ²²⁾ (2022)	Liu Zi Jue training+conventional rehabilitation treatment	Core stability training+conventional rehabilitation treatment	50 min, 5 times/week for 4 weeks	BBS, FMA, MBI, MPT, diaphragm thickness, mobility, diaphragm thickening fraction
Liu et al. ²⁴⁾ (2023)	Acupuncture combined with TCM guidance on the basis of control group	Routine rehabilitation training combined with respiratory training	Routine rehabilitation training 30~45 mins, 5 times/week Respiratory training 15~20 mins, 3~4 times/day Acupuncture 25 min, 1 time/day TCM guidance for 8 weeks	FMA, SS-QOL, BBS, diaphragmatic thickness, diaphragmatic activity, abdominal external oblique muscle, abdominal transverse muscle, abdominal internal oblique muscle, adverse reactions
Cui et al. ²⁶⁾ (2023)	“Taking the Waist as the Axis” therapy+conventional therapy	“Trunk Selective Activity” therapy+conventional therapy	50 min, 5 times/week for 3 weeks	TIS, FMA, BBS, IAP, MBI, COP, MIP, MEP, FEV ₁ , FVC, PEF, MMEF
Xia et al. ²⁵⁾ (2023)	Liu Zi Jue Qigong+conventional speech therapy	Conventional speech therapy	40 min, 5 times/week for 4 weeks	FDA, speech articulation, MPT, loudness, MoCA
Zhang et al. ²¹⁾ (2024)	Liu Zi Jue respiratory exercise+conventional occupational therapy	Conventional occupational therapy	30 min, 1 time/day, 4 days/week for 6 months	FVC, FEV ₁ , LVEF, LVEDD, BBS

TIS: trunk impairment scale, MIP: maximum inspiratory pressure, MEP: maximum expiratory pressure, FEV₁: forced expiratory volume in the first second, FVC: forced vital capacity, PEF: peak expiratory flow, MMEF: maximum expiratory mid-flow, IAP: the change of intra-abdominal pressure, BBS: Berg balance scale, MBI: modified Barthel index, FDA: Frenchay dysarthria assessment, MPT: maximum phonation time, FMA: Fugl-Meyer assessment, SS-QOL: stroke-specific quality of life, COP: center of pressure, MoCA: Montreal cognitive assessment scale, LVEF: left ventricular ejection fraction, LVEDD: left ventricular end-diastolic diameter.

^{*}Maximum duration of sustained voiceless /s/ phonation.

[†]Maximum duration of sustained voiced /z/ phonation.

[‡]Ratio of maximum /s/ phonation time to maximum /z/ phonation time.

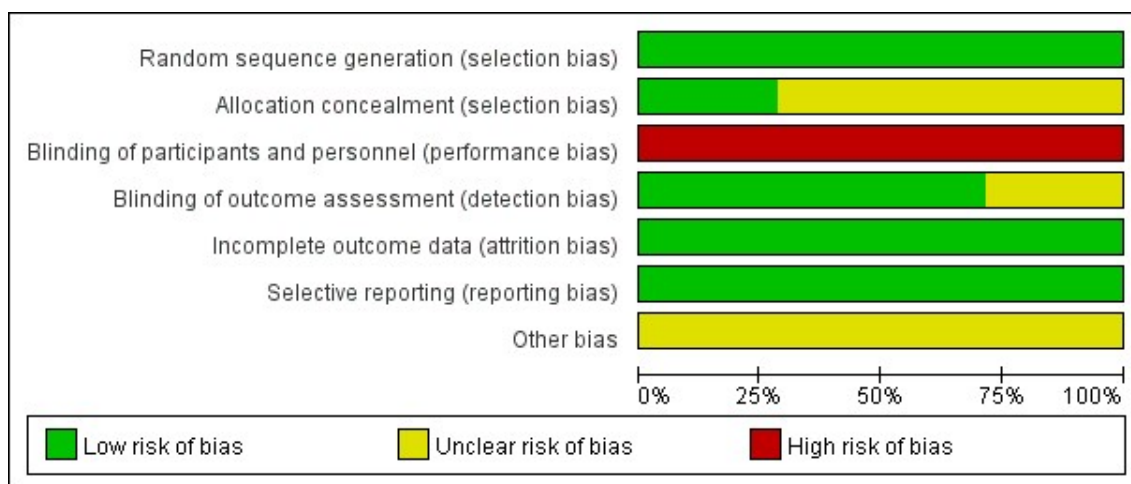


Fig. 2. Risk of bias graph.

3. Risk of bias

The Cochrane RoB 1.0 tool¹⁹⁾ appraised all seven trials (Figs. 2, 3).

All studies used valid random-sequence methods (e.g., computer generation, random tables), yielding a low risk for randomization bias. However, allocation concealment was not described in five studies^{21,22,24,25,27)}, creating unclear selection-bias risk.

Blinding of participants and personnel was uniformly rated high risk due to the active nature of Dao-yin exercises, which precludes masking and may introduce performance bias. Outcome assessor blinding was low risk in five studies with independent evaluators, but two studies^{21,22)}, lacked clarity, resulting in “some concerns” for potential detection bias. Attrition and selective-reporting biases were low risk across all studies, as dropout rates were minimal and reported outcomes matched protocols. Concerns in the “other bias” domain arose from single-center designs and short intervention periods (e.g., three weeks), which may limit generalizability and long-term effect appraisal.

In summary, despite robust randomization and reporting, the lack of participant/personnel blinding and unclear allocation concealment and assessor blinding warrant caution in interpreting the pooled results.

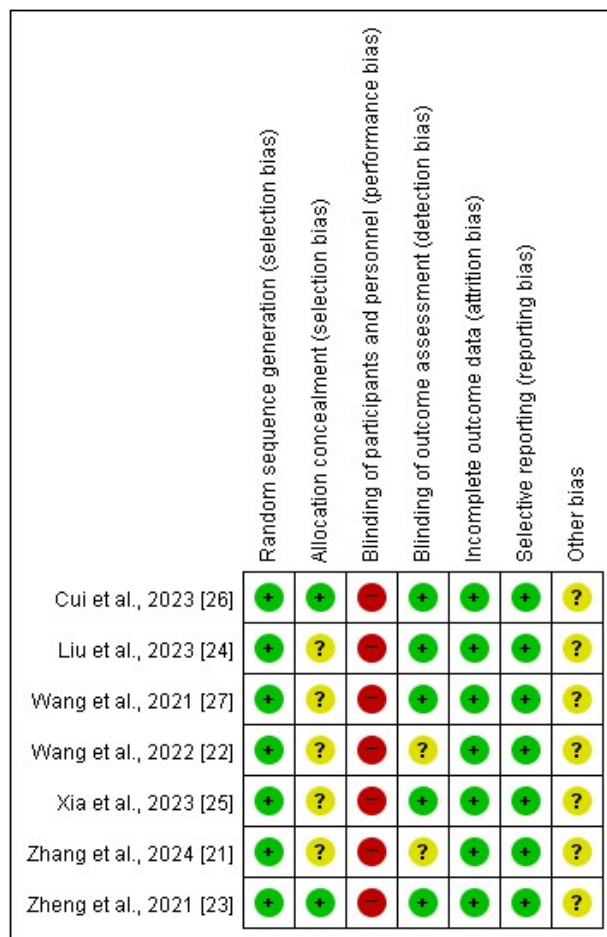


Fig. 3. Risk of bias summary.

4. Meta-analyses

1) Primary outcomes

(1) Respiratory muscle strength

The meta-analysis for MIP included two studies^{23,26)} (Fig. 4) comprising 100 participants (52 in the experimental group and 48 in the control group). The effect on MIP was not statistically significant (MD=2.45, 95% CI, -14.09 to 19.00; $Z=0.29$, $p=0.77$), with high heterogeneity ($I^2=78\%$). Substantial heterogeneity may reflect differences in stroke chronicity, intervention duration, and baseline respiratory function across studies. Thus, the effects of Dao-yin intervention on inspiratory muscle strength remain inconclusive. Further high-quality RCTs with standardized methodologies and larger sample sizes are required to clarify the clinical efficacy of MIP.

For MEP, two studies^{23,26)} with a total of 100 participants were analyzed (Fig. 5). The meta-analysis demonstrated a statistically significant improvement in the experimental group compared to the control group (MD=8.68, 95% CI, 2.25 to 15.10; $Z=2.64$, $p=0.008$), with no heterogeneity detected ($I^2=0\%$). The absence of heterogeneity suggests a high degree of consistency be-

tween the studies, reinforcing the reliability of the findings. Thus, Dao-yin interventions may effectively enhance expiratory muscle strength in patients with stroke, with potential clinical implications for respiratory rehabilitation. As Cui et al.²⁶⁾ reported median and interquartile range (IQR) values, appropriate statistical conversions were applied to estimate the mean and SD for inclusion in the meta-analysis. Although these findings provide evidence supporting the efficacy of Dao-yin therapy in improving MEP, further large-scale, rigorously designed RCTs are required to establish definitive clinical recommendations.

(2) Pulmonary function

The meta-analysis of FVC included three studies^{21,23,26)} (Fig. 6) comprising 220 participants (112 in the experimental group and 108 in the control group). Since Zheng et al.²³⁾ reported FVC/L (% predicted), whereas other studies provided absolute values, SMD was used for the analysis instead of MD. A non-significant difference in favor of the Dao-yin intervention was observed (SMD=0.72, 95% CI, -0.48 to 1.92; $Z=1.18$, $p=0.24$). However, a substantial heterogeneity was observed ($I^2=94\%$).

For FEV₁, three studies^{21,23,26)} were analyzed, with

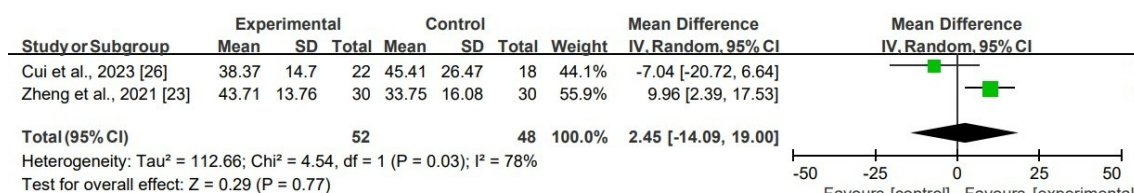


Fig. 4. Meta-analysis of the effect of Dao-yin exercise therapy on maximum inspiratory pressure. SD: standard deviation, CI: confidence interval.

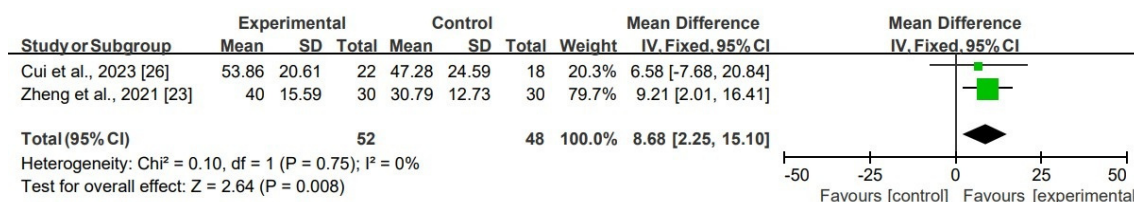


Fig. 5. Meta-analysis of the effect of Dao-yin exercise therapy on maximum expiratory pressure. SD: standard deviation, CI: confidence interval.

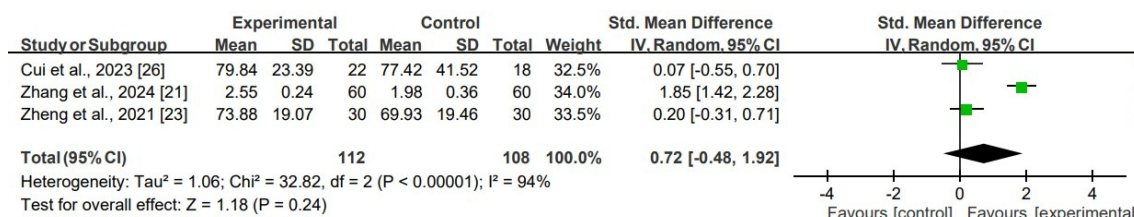


Fig. 6. Meta-analysis of the effect of Dao-yin exercise therapy on forced vital capacity. SD: standard deviation, CI: confidence interval.

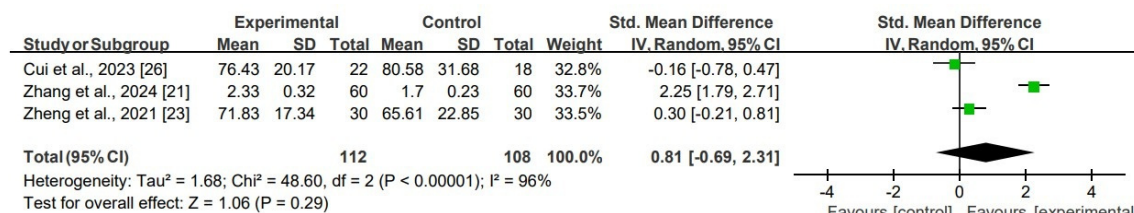


Fig. 7. Meta-analysis of the effect of Dao-yin exercise therapy on forced expiratory volume in 1 second. SD: standard deviation, CI: confidence interval.

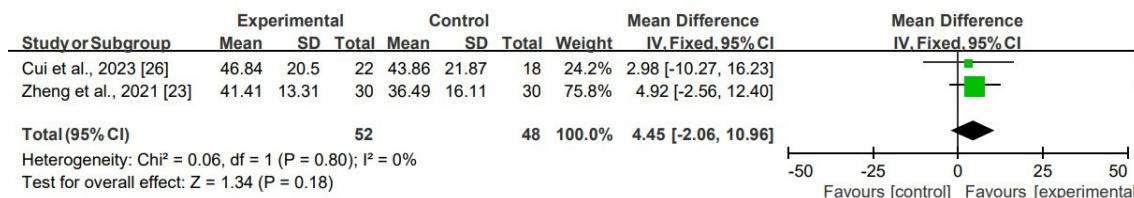


Fig. 8. Meta-analysis of the effect of Dao-yin exercise therapy on peak expiratory flow. SD: standard deviation, CI: confidence interval.

Zheng et al.²³⁾ reporting FEV_1/L (% predicted), necessitating the use of SMD for comparability (Fig. 7). The results did not show a statistically significant improvement (SMD=0.81, 95% CI, -0.69, to 2.31; $Z=1.06$, $p=0.29$), with a high heterogeneity level ($I^2=96\%$).

2) Secondary outcomes

(1) Pulmonary function

The analysis of PEF included two studies^{23,26)} (Fig. 8) with 100 participants (52 in the experimental group and 48 in the control group). The pooled results indicated a mean difference of 4.45 (95% CI, -2.06 to 10.96), although the difference was not statistically significant ($Z=1.34$, $p=0.18$). Heterogeneity was minimal ($I^2=0\%$).

Two studies were analyzed for maximum mid-ex-

piratory flow (MMEF)^{23,26)} (Fig. 9). The pooled analysis showed no significant difference (MD=3.36, 95% CI, -7.60 to 14.33; $Z=0.60$, $p=0.55$, $I^2=5\%$).

The meta-analysis of the MPT included three studies^{22,25,27)} (Fig. 10), with a total of 231 participants (115 in the experimental group and 116 in the control group). Since Wang et al.²⁷⁾ reported the mean and 95% CIs rather than SDs, statistical conversion was applied for inclusion in the meta-analysis. The pooled results demonstrated a significant improvement in the Dao-yin intervention group (MD=1.48, 95% CI, 0.62 to 2.34; $Z=3.37$, $p=0.0007$) with minimal heterogeneity ($I^2=0\%$), indicating consistent effects across studies. This robust and precise improvement suggests that Dao-yin exercise therapy can effectively enhance expiratory control and phonatory

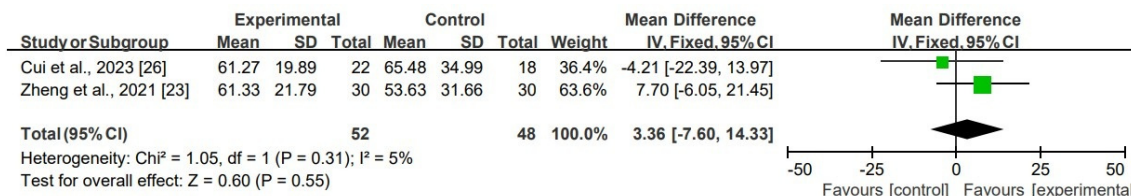


Fig. 9. Meta-analysis of the effect of Dao-yin exercise therapy on maximum mid-expiratory flow. SD: standard deviation, CI: confidence interval.

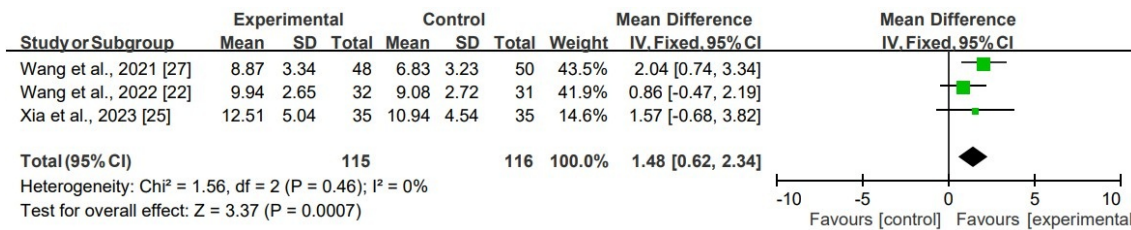


Fig. 10. Meta-analysis of the effect of Dao-yin exercise therapy on maximum phonation time. SD: standard deviation, CI: confidence interval.

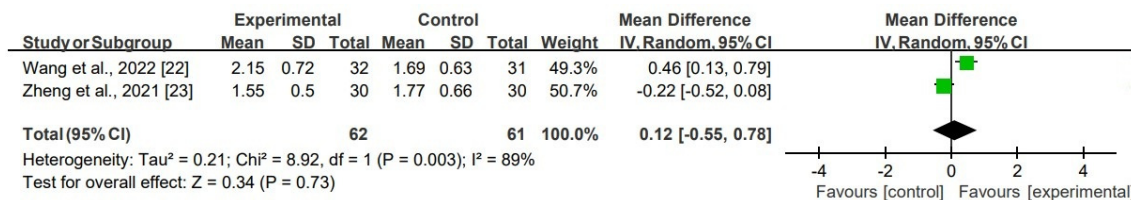


Fig. 11. Meta-analysis of the effect of Dao-yin exercise therapy on diaphragmatic mobility at resting inspiration. SD: standard deviation, CI: confidence interval.

function, which may be particularly beneficial in patients with stroke, dysarthria, or reduced respiratory endurance.

(2) Diaphragm function (diaphragmatic mobility at resting inspiration, diaphragmatic mobility at maximum expiration)

The meta-analysis of diaphragmatic mobility at resting inspiration included two studies with 123 participants (62 experimental and 61 control)^{22,23)} (Fig. 11). The pooled results showed a non-significant mean difference (MD=0.12, 95% CI, -0.55 to 0.78), with substantial heterogeneity ($I^2=89\%$). The test for the overall effect did not indicate statistical significance ($Z=0.34$, $p=0.73$), suggesting that Dao-yin intervention did not lead to a meaningful improvement in diaphragmatic mobility during resting inspiration.

For diaphragmatic mobility at maximum expiration, the same two studies^{22,23)} comprising 123 participants were analyzed (Fig. 12). The results indicated a mean difference of 0.24 (95% CI, -0.20 to 0.68), with moderate heterogeneity ($I^2=40\%$). The overall effect was also not significant ($Z=1.08$, $p=0.28$), implying that the intervention did not result in a substantial improvement in diaphragmatic mobility at maximum expiration.

No statistically significant differences were identified in diaphragmatic mobility during either resting inspiration or maximum expiration, suggesting limited evidence for a diaphragm-specific effect of Dao-yin intervention.

(3) Balance function

The BBS analysis included five studies^{21-24,26)} (Fig. 13) with 406 participants (205 experimental, 201 con-

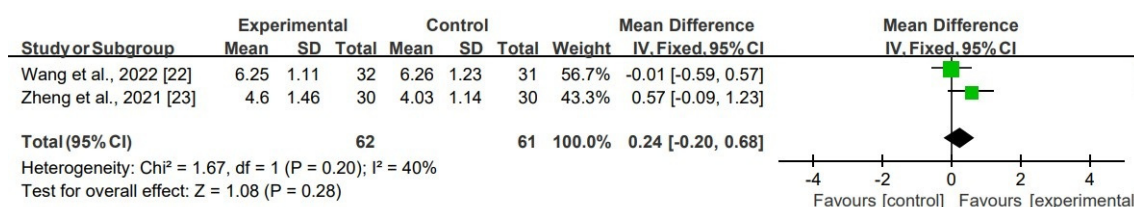


Fig. 12. Meta-analysis of the effect of Dao-yin exercise therapy on diaphragmatic mobility at maximum expiration. SD: standard deviation, CI: confidence interval.

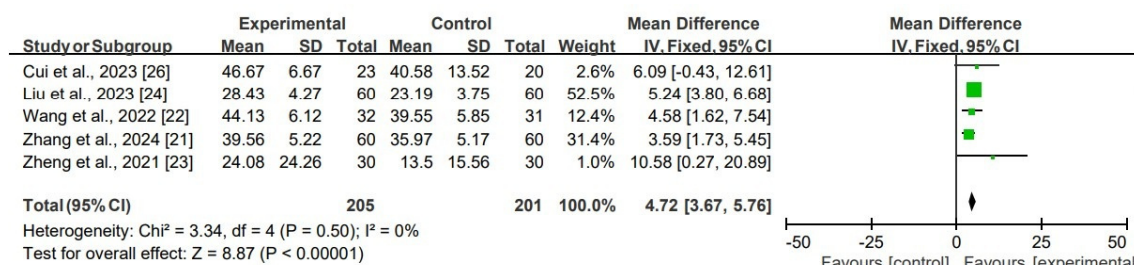


Fig. 13. Meta-analysis of the effect of Dao-yin exercise therapy on Berg balance scale. SD: standard deviation, CI: confidence interval.

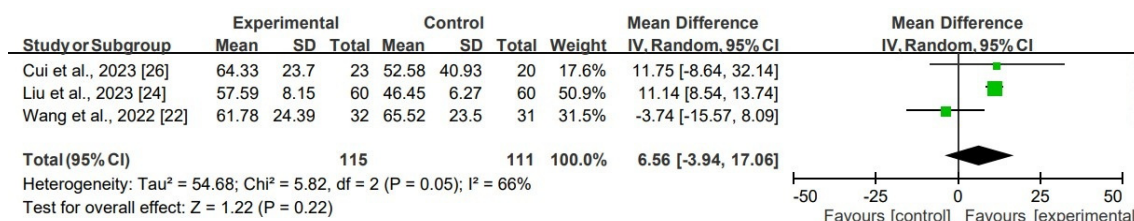


Fig. 14. Meta-analysis of the effect of Dao-yin exercise therapy on Fugl-Meyer assessment. SD: standard deviation, CI: confidence interval.

trol). Zhang et al.²¹⁾ originally reported BBS scores using a 56-point scale, which was converted to a 100-point scale for consistency in the meta-analysis. Additionally, the studies conducted by Cui et al.²⁶⁾ and Zheng et al.²³⁾ presented median and IQR values that were appropriately converted into mean and standard deviation values. A pooled analysis demonstrated a significant improvement in balance function, favoring Dao-yin intervention (MD=4.72, 95% CI, 3.67 to 5.76; $Z=8.87$, $p<0.0001$). Heterogeneity among the studies was low ($I^2=0\%$), supporting the robustness of the findings.

(4) Motor function

The FMA was analyzed in three studies^{22,24,26)} (Fig. 14), including 226 participants (115 experimental, 111

control). Although the intervention group showed significantly improved FMA scores (MD=6.56, 95% CI, -3.94 to 17.06; $Z=1.22$), the difference was not statistically significant ($p=0.22$). The moderate heterogeneity ($I^2=66\%$) suggests that variations in study protocols or participant characteristics may have influenced the observed effect size.

(5) Activities of daily living (ADL) function

For the MBI, three studies^{22,23,26)} (Fig. 15) with 166 participants (85 experimental, 81 control) were included. ADL function significantly improved in the experimental group (MD=6.85, 95% CI, 3.16 to 10.54; $Z=3.64$, $p=0.0003$). The heterogeneity was low ($I^2=0\%$), reinforcing the reliability of the finding that Dao-yin inter-

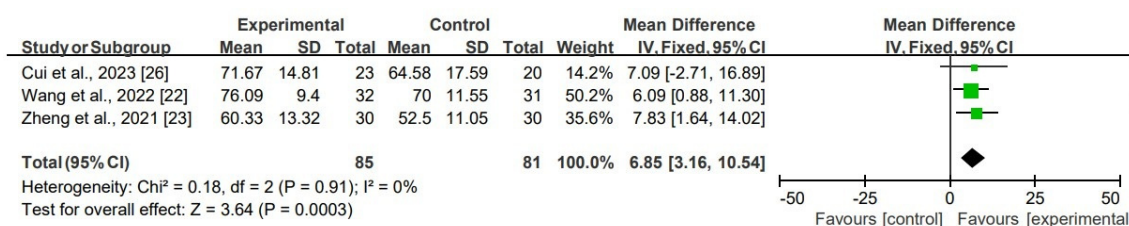


Fig. 15. Meta-analysis of the effect of Dao-yin exercise therapy on modified Barthel index. SD: standard deviation, CI: confidence interval.

ventions can enhance daily functional independence in patients with stroke.

5. Adverse events

Among the seven included studies, three^{24,26,27)} reported adverse effects. Two of these studies^{26,27)} explicitly stated that no adverse effects were observed. In the remaining study²⁴⁾, adverse effects were documented in both the treatment and control groups, with 3 of 60 participants (5%) in the treatment group and 12 of 60 participants (20%) in the control group experiencing such events. In the treatment group, the adverse events included nausea ($n=2$) and vomiting ($n=1$), whereas in the control group, the adverse events included dizziness ($n=3$), nausea ($n=6$), and vomiting ($n=3$).

Discussion»»»»

This systematic review and meta-analysis evaluated the effects of comprehensive rehabilitation interventions incorporating Dao-yin exercise therapy on respiratory function in patients with stroke by synthesizing data from seven RCTs. Respiratory dysfunction remains a frequently overlooked complication following stroke, yet it substantially affects recovery trajectories. This study provides preliminary evidence suggesting that Dao-yin exercise therapy may serve as an adjunct to conventional rehabilitation; however, given the methodological limi-

tations of the included studies, these findings should be interpreted cautiously.

The pooled results demonstrated statistically significant improvements in MEP ($MD=8.68$, $p=0.008$), MPT ($MD=1.48$, $p=0.0007$), balance (BBS; $MD=4.72$, $p<0.0001$), and activities of daily living (MBI; $MD=6.85$, $p=0.0003$), suggesting that comprehensive interventions incorporating Dao-yin exercise therapy may confer some benefits in select functional outcomes in stroke rehabilitation. In contrast, no statistically significant effects were observed for MIP, pulmonary capacity (FVC and FEV_1), peak flow measures (PEF and MMEF), diaphragmatic mobility, or motor function (FMA)²¹⁻²⁷⁾.

The observed improvements in MEP and MPT suggest that Dao-yin exercises may contribute to improvements in expiratory muscle strength and respiratory-laryngeal coordination. These functions are closely associated with airway clearance, voice control, and breathing stability, which are relevant to post-stroke rehabilitation. The structure of Dao-yin, particularly in forms such as Liu Zi Jue, incorporates controlled expiration and vocalization, which may partly explain the consistent gains observed in these specific domains.

Balance and ADL improvements also suggest possible neuromuscular benefits of Dao-yin. Repetitive symmetrical movements and breathing-focused postural control may improve proprioception, trunk stability, and functional mobility. These results are broadly consistent with previous findings on mind-body exercises that integrate motor and respiratory coordination.

Regarding potential mechanisms, diaphragmatic breath-

ing and progressive respiratory muscle activation inherent in Dao-yin protocols may contribute to improved ventilatory efficiency and gas exchange. However, the mechanistic basis for the observed outcomes remains speculative, as none of the included studies incorporated objective physiological assessments such as diaphragmatic ultrasound or arterial blood gas analysis. These mechanistic explanations should therefore be regarded as hypotheses to be examined in future studies³⁴⁻³⁶.

Regarding safety, three adverse events were reported across the included studies. While none were classified as severe, the small number of participants across studies and the limited detail in adverse event reporting preclude any definitive conclusions regarding the safety profile of this intervention. Future studies should prospectively register and systematically report adverse events using standardized criteria to enable a more rigorous safety evaluation.

Although MIP, FVC, FEV₁, PEF, and diaphragmatic mobility did not demonstrate statistically significant improvements, most outcomes showed trends that favoring the intervention group. The absence of significance may reflect methodological heterogeneity, small sample sizes, and insufficient targeting of inspiratory muscle function within the Dao-yin protocols. Similarly, motor function as measured by the FMA did not improve significantly, possibly owing to the low intensity or brief duration of the interventions. These non-significant findings do not exclude the potential benefits but likely reflect limited statistical power and variability across study designs.

Compared with previous studies, this review adds quantitative data to the broader question of whether Dao-yin interventions improve selected aspects of respiratory and physical function in patients with stroke. Although earlier reports have highlighted the general pulmonary benefits of Qigong or Tai Chi^{37,38}, few studies have systematically examined stroke-specific respiratory outcomes. This review addresses that gap; however, the current evidence base remains insufficient to support definitive clinical recommendations for Dao-yin as a res-

piratory rehabilitative intervention in stroke.

This study has several limitations. First, the number of included studies was small, and several analyses were based on only two or three trials, substantially limiting statistical power and robustness of findings. Second, considerable methodological heterogeneity was present, with marked variations in intervention protocols, outcome measures, and control group treatments, which restricted direct comparability across studies. Third, blinding was inadequate in most studies; the absence of participant and assessor blinding introduces a substantial risk of performance and detection bias, and no included study achieved full allocation concealment. Fourth, all included trials were conducted in China, which raises concerns about geographical publication bias and limits the generalizability of findings to broader international populations. Fifth, and critically, Dao-yin exercise therapy was administered as a component of multicomponent rehabilitation programs in all included studies, consistently delivered in combination with conventional physical or occupational therapy. This co-intervention structure makes it inherently difficult to isolate the independent contribution of Dao-yin from the overall rehabilitative effect; observed improvements should therefore be attributed to the comprehensive program rather than to Dao-yin alone. These limitations collectively highlight the need for rigorously designed, multicenter RCTs with standardized protocols, adequate allocation concealment, and objective outcome assessments.

The findings of this review indicate that comprehensive rehabilitation incorporating Dao-yin exercise therapy was associated with statistically significant improvements in expiratory muscle strength, phonation time, balance, and certain activities of daily living. However, the clinical relevance of these findings remains uncertain given the methodological limitations of the included studies. No significant effects were observed for overall respiratory capacity, inspiratory muscle performance, or motor function. In light of the complex nature of the interventions, the prevalent methodological short-

comings, and the limited adverse event data, these results should not be generalized beyond the scope of the current evidence.

Future studies should focus on large-scale, multicenter RCTs with clearly defined and standardized Dao-yin protocols, including specified exercise type, frequency and intensity. Long-term follow-up assessments are necessary to determine whether the observed improvements are sustained beyond the intervention period. Objective physiological measurements, including diaphragmatic ultrasound and formal pulmonary function testing, should be incorporated to reduce measurement bias. Furthermore, future research designs should either employ Dao-yin as a standalone intervention or rigorously control for concurrent therapies to enable a more precise estimation of its independent effects.

Conclusions»»»»

This systematic review and meta-analysis provides preliminary evidence that comprehensive rehabilitation programs incorporating Dao-yin exercise therapy may yield improvements in certain functional outcomes among patients with stroke. Statistically significant effects were observed in MEP (MD=8.68, $p=0.008$), maximum phonation time (MD=1.48, $p=0.0007$), balance function (BBS) (MD=4.72, $p<0.0001$), and activities of daily living (MBI) (MD=6.85, $p=0.0003$), whereas no significant effects were identified for maximum inspiratory pressure, pulmonary capacity indices (FVC and FEV₁), peak flow measures, diaphragmatic mobility, or motor function (FMA). Notably, Dao-yin was delivered exclusively as part of multicomponent rehabilitation programs in all included studies; therefore, the observed improvements should be attributed to the comprehensive intervention rather than to Dao-yin alone. Given the methodological limitations of the current evidence, future research should prioritize large-scale multicenter RCTs with

standardized protocols, rigorous control of concurrent therapies, and objective physiological assessments to establish more definitive clinical recommendations.

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Appendix I. Search Strategy for the PubMed Database

Search term	
#1	qigong(MeSH Terms) OR tai ji[MeSH Terms]
#2	“DaoYin”(Title/Abstract) OR “daoyin”(Title/Abstract)
#3	“Ba Duan Jin”(Title/Abstract) OR “Eight Fragments”(Title/Abstract) OR “eight section brocade”(Title/Abstract) OR “eight trigrams boxing”(Title/Abstract)
#4	“Yi Jin Jing”(Title/Abstract) OR “yijinjing”(Title/Abstract)
#5	“Wu Qin Xi”(Title/Abstract) OR “wuqinxi”(Title/Abstract)
#6	“Liu Zi Jue”(Title/Abstract) OR “liuzijue”(Title/Abstract)
#7	“Tai Chi”(Title/Abstract) OR “taiji”(Title/Abstract) OR “taichi”(Title/Abstract) OR “Tai Ji”(Title/Abstract)
#8	“Qi Gong”(Title/Abstract) OR “qigong”(Title/Abstract) OR “Ch'I Kung”(Title/Abstract) OR “Chi gung”(Title/Abstract) OR “Qi Training”(Title/Abstract)
#9	#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8
#10	“stroke”(MeSH Terms) OR “stroke rehabilitation”(MeSH Terms) OR “brain ischemia”(MeSH)
#11	“stroke”(Title/Abstract) OR “cerebrovascular accident”(Title/Abstract) OR “CVA”(Title/Abstract) OR “apoplexy”(Title/Abstract) OR “post-stroke”(Title/Abstract)
#12	#10 OR #11
#13	“Randomized Controlled Trial”(PT) OR “Controlled Clinical Trial”(PT)
#14	“Clinical Trials as Topic”(MeSH Terms)
#15	randomized(TIAB) OR placebo(TIAB) OR randomly(TIAB) OR trial(TIAB)
#16	#13 OR #14 OR #15
#17	#9 AND #12 AND #16

Appendix II. Search Strategy for the Cochrane Library Database

Search term	
#1	(mh Qigong) OR (mh “Tai Ji”)
#2	(dao-yin OR Dao-yin OR Qi Gong OR qigong OR qi training OR chi kung OR Ba Duan Jin OR badunajin OR eight fragments OR eight section brocade OR eight trigrams boxing OR wuqinxi OR Wu Qin Xi OR Yi Jin Jing OR yijinjing OR Tai Chi OR taiji OR taichi OR Tai Ji OR liuzijue OR Liu Zi Jue):ti,ab,kw
#3	(mh stroke) OR (mh “stroke rehabilitation”)
#4	(stroke OR “cerebrovascular accident” OR CVA OR “cerebrovascular disease” OR “brain vascular accident” OR apoplexy OR “post-stroke”):ti,ab,kw
#5	#1 OR #2
#6	#3 OR #4
#7	#5 AND #6
#8	(mh “randomized controlled trial”)
#9	(“Randomized Controlled Trial”):pt OR (“Controlled Clinical Trial”):pt OR (randomized):ti,ab,kw OR (placebo):ti,ab,kw OR (randomly):ti,ab,kw OR (trial):ti,ab,kw
#10	#8 OR #9
#11	#7 AND #10

Appendix III Search Strategy for the Embase Database

Search term	
#1	“daoyin”/exp OR “tai chi”/exp OR “qigong”/exp OR “baduanjin”/exp OR “wuqinxi”/exp OR “yijinjing”/exp OR “liuzijue”/exp
#2	“dao-yin”:ab,ti OR “qi gong”:ab,ti OR qigong:ab,ti OR daoyin:ab,ti OR “chi gung”:ab,ti OR wuqinxi:ab,ti OR baduanjin:ab,ti OR yijinjing:ab,ti OR “ba duan jin”:ab,ti OR “wu qin xi”:ab,ti OR “yi jinjing”:ab,ti OR liuzijue:ab,ti OR “tai chi”:ab,ti OR taichi:ab,ti OR taiji:ab,ti OR “tai ji”:ab,ti OR “chi kung”:ab,ti OR “eight section brocade”:ab,ti OR “eight fragments”:ab,ti OR “eight trigrams boxing”:ab,ti
#3	“cerebrovascular accident”/exp OR “stroke rehabilitation”/exp OR “stroke”:ti,ab,kw OR “cerebrovascular accident”:ti,ab,kw OR “cva”:ti,ab,kw OR “cerebrovascular disease”/exp OR “brain ischemia”/exp OR “apoplexy”:ti,ab,kw OR “post-stroke”:ti,ab,kw
#4	“randomized controlled trial”/exp OR “randomized controlled trial”:it OR “controlled clinical trial”:it OR randomized:ti,ab,kw OR placebo:ti,ab,kw OR randomly:ti,ab,kw OR trial:ab,ti OR “clinical trials”:ti,ab,kw
#5	#1 OR #2
#6	#5 AND #3 AND #4

Appendix IV. Search Strategy for the China National Knowledge Infrastructure Database

Search terms	
#1	SU=(导引) OR SU=(八段锦) OR SU=(易筋经) OR SU=(五禽戏) OR SU=(气功) OR SU=(六字诀) OR SU=(太极拳)
#2	SU=(脑卒中) OR SU=(中风) OR SU=(卒中后)
#3	SU=(随机对照试验临床) OR SU=(随机对照试验) OR SU=(对照临床试验) OR SU=(安慰剂) OR SU=(临床试验) OR SU=(试验) OR SU=(randomized controlled trial) OR SU=(controlled clinical trial)
#4	#1 AND #2 AND #3