The Efficacy of Lower Extremity Mirror Therapy for Improving Balance, Gait, and Motor Function Poststroke: A Systematic Review and Meta-Analysis

Dennis R. Louie, BSc, PT,*'† Shannon B. Lim, MSc, PT,*'† and Janice J. Eng, PhD, PT†'‡

Background: Mirror therapy is less commonly used to target the lower extremity after stroke to improve outcomes but is simple to perform. This review and meta-analysis aimed to evaluate the efficacy of lower extremity mirror therapy in improving balance, gait, and motor function for individuals with stroke. *Methods:* PubMed, Cochrane Central Register of Controlled Trials, MEDLINE, Embase, Cumulative Index to Nursing and Allied Health Literature, Physiotherapy Evidence Database, and PsychINFO were searched from inception to May 2018 for randomized controlled trials (RCTs) comparing lower extremity mirror therapy to a control intervention for people with stroke. Pooled effects were determined by separate meta-analyses of gait speed, mobility, balance, and motor recovery. *Results:* Seventeen RCTs involving 633 participants were included. Thirteen studies reported a significant between-group difference favoring mirror therapy in at least one lower extremity outcome. In a meta-analysis of 6 trials that reported change in gait speed, a large beneficial effect was observed following mirror therapy training (standardized mean differences [SMD] = 1.04 [95% confidence interval [CI] = .43, 1.66], $I^2 = 73\%$, and $P < .001$). Lower extremity mirror therapy also had a positive effect on mobility (5 studies, SMD = .46 [95% CI = .01, .90], $I^2 = 43\%$, and $P = .05$) and motor recovery (7 studies, SMD = .47 [95% CI = .21, .74], $I^2 = 0\%$, and $P < .001$). A significant pooled effect was not found for balance capacity. *Conclusions:* Mirror therapy for the lower extremity has a large effect for gait speed improvement. This review also found a small positive effect of mirror therapy for mobility and lower extremity motor recovery after stroke.
Key Words: Stroke—mirror therapy—gait—balance—mobility—motor recovery

Introduction

Stroke often results in lasting physical, sensory, cognitive, and visual impairments, ultimately leading to a reduction in an individual's ability to perform various activities of daily living, such as dressing, feeding, and walking.[1,2] Unsurprisingly, stroke is a leading cause of adult disability,[3] with most rehabilitation hospitals having specifically dedicated units for stroke survivors. Despite the functional gains experienced in rehabilitation,[4] many

stroke survivors are still limited in their balance and walking ability well into the chronic phase of the disease.[5-7] This in turn can influence the discharge destination and community involvement of stroke survivors.[8,9] As the number of stroke survivors grows over the next decade,[10] improving the efficiency and availability of rehabilitation (staffing resources and group classes) becomes increasingly imperative. Furthermore, it has been shown that stroke patients are largely sedentary, even during their inpatient rehabilitation stay[11] and more so after discharge from hospital.[12] It is essential to determine safe, cost-effective methods to increase patient activity that may stimulate further functional improvements.

Mirror therapy is a low-cost and accessible therapy that has been suggested to promote neuroplastic change in the brain for pain relief, sensory normalization, and motor recovery.[13] Mirror therapy is performed by positioning a mirror in the midsagittal plane to replace the image of the affected limb with a reflection of the unaffected side, while receiving physical stimulation or performing movement tasks. This gives the visual illusion of the affected limb functioning normally. Mirror therapy has largely been used for phantom limb pain after amputation[14] and upper limb motor recovery poststroke.[15] The underlying mechanism by which mirror therapy stimulates neural recovery in the brain is still unclear, though a systematic review of neuroimaging research[13] has shown that mirror therapy leads to broad activation spanning attention and cognitive centres, bilateral motor cortices, some areas within the mirror neuron system, as well as decreases in intracortical inhibition to the affected hemisphere.

The use of mirror therapy after stroke has predominantly centered around the hemiparetic upper limb. This is unsurprising, given the ease of setting up mirror therapy on a desk, as well as the many functional movements that can be performed and retrained at the hand and wrist. Multiple systematic reviews have investigated the effect of mirror therapy on upper limb recovery. Thieme et al in 2013[16] found that mirror therapy has a significant effect on motor function and improved activities of daily living. Likewise, in 2017 Zeng et al[15] found a moderate effect of mirror therapy on motor function of the upper extremity. Additionally, several randomized controlled trials (RCTs) have found mirror therapy to have efficacy for reducing pain in the upper limb for stroke patients with complex regional pain syndrome.[17,18]

Despite the numerous experimental studies and reviews focusing on mirror therapy for upper extremity pain management and motor recovery after stroke, there has been sparse attention given to using mirror therapy for the lower extremity poststroke. However, given the nature of mirror therapy as a potentially repetitious, safe, and cost-effective exercise modality, it may offer an option to therapists to enhance their patients' rehabilitation regimen. Hung et al conducted the first

review of lower extremity mirror therapy in 2015,[19] which identified 14 articles and included only 4 RCTs. Their review suggested that mirror therapy may be beneficial in improving motor function in the hemiparetic lower extremity of stroke survivors, but further conclusive research is needed. There have since been numerous RCTs published which have investigated the efficacy of lower extremity mirror therapy after stroke. These studies were included in 2 recent systematic reviews and meta-analyses which showed improved balance, mobility, gait speed, and motor function after mirror therapy compared to a control group.[20,21] Despite these recent reviews, several methodological limitations make it difficult to fully determine which aspects of stroke recovery it may improve and who may benefit the most from mirror therapy.

Purpose

Mirror therapy has the potential to be utilized as a safe adjunctive therapy for lower extremity task-practice, which may in turn promote physical and functional recovery after stroke. This systematic review and meta-analysis will address the efficacy of lower extremity mirror therapy compared to a control intervention for recovery of balance, mobility, gait speed, and motor function after stroke. It will also investigate potential moderators of the effect, including timing of intervention and how it is performed.

Methods

The protocol for this systematic review was registered in the International prospective register of systematic reviews, PROSPERO (CRD42018090225). We followed the steps outlined in the Cochrane Handbook for Systematic Reviews of Interventions (Version 5.1.0)[22] to establish the research question and search strategies and to undertake the meta-analysis.

Data Sources and Searches

A literature search was performed from inception until May 22, 2018 in the electronic databases: PubMed (since 1946), MEDLINE (since 1946), Cochrane central register of controlled trials (1991), Embase (since 1974), Cumulative Index to Nursing and Allied Health Literature (since 1982), Physiotherapy Evidence Database (since 1999), and PsychINFO (since 1967). Search terms combined keywords related to stroke (eg, "cerebrovascular accident," "cerebral infarct," and "intracerebral hemorrhage"), mirror therapy (eg, "mirror box," and "visual mirror feedback"), and mobility recovery (eg, "walking," "balance," and "lower extremity"). A detailed list of the keywords, MeSH terms, and search strategy for PubMed is included as Appendix 1. The returned titles and abstracts were independently screened by 2 reviewers (D.R.L., S.B.L.) to

identify potentially relevant studies. Reference lists of included full-texts and relevant reviews were hand-searched for additional references.

Study Selection

Full-text journal articles were eligible for selection if they met the following inclusion criteria: (a) the study was a RCT; (b) an outcome relating to balance, mobility, gait, or lower extremity motor function was measured; (c) participants were adults (18 or older) with stroke; (d) the mirror therapy intervention targeted the lower extremity and replaced the image of the hemiparetic lower extremity with a reflection of the unaffected side; and (e) the study was published in English. Studies that included supplemental stimulation (electric and magnetic) with mirror therapy were also included. Studies in which the mirror placement did not obscure the affected lower extremity were excluded (ie, mirror placed in front to provide visual feedback of whole body).

Data Extraction and Quality Assessment

The included articles were reviewed by 2 independent researchers (D.R.L., S.B.L.) to extract data regarding the study sample (age, sex, time since stroke, and type of stroke), intervention (content, duration, frequency, control comparison, and adverse events), and outcome measure findings of gait, balance, mobility, and motor impairment. The 2 researchers independently assessed study quality and risk of bias for each RCT using the Cochrane Collaboration's Tool for Assessing Risk of Bias[22]; discrepancies in quality rating were resolved by discussion. If consensus was not reached, a third reviewer (J.J.E.) was consulted. The types of risk assessed using this tool consist of selection bias (randomization and allocation concealment), performance bias (subject, therapist, and assessor blinding), attrition bias (incomplete outcome data), reporting bias (selective outcome reporting), and other potential biases specific to each study. Each criterion is judged to be "low risk," "high risk," or "unclear risk" and displayed in a table, rather than summating a total score. This method of quality assessment has been recommended,[23,24] as providing a summary score equally weights all errors and may potentially result in a glaring methodological flaw being overlooked (eg, inadequate randomization) if only a high summary score is presented.

Data Synthesis and Analysis

Study and participant characteristics, intervention content and dose, and main findings were qualitatively synthesized. Meta-analyses of change scores to summarize the effect of mirror therapy on gait speed, balance, mobility, and motor recovery were conducted using Review Manager software, version 5.3.5 (Review Manager, 2014). We expressed the pooled effects as standardized mean differences (SMD) and 95% confidence intervals (CIs) to accommodate for the variability in outcome measurement and reporting (different measures and units) across the included studies. We classified a SMD of .2-.49 as a small effect, a SMD of .5-.79 as a moderate effect, and a SMD $\geq$ .8 as a large effect.[22] Random effects models were used, as significant heterogeneity was expected from clinical and methodological differences between studies. Heterogeneity was summarized using the I-squared (I^2) statistic, which indicates the percentage of variability attributable to the heterogeneity of the included studies; we classified an I^2 value between 25% and 50% as low heterogeneity, between 50% and 75% as moderate heterogeneity, and greater than 75% as high heterogeneity (Higgins, 2011). Clinical and methodological heterogeneity was further explored by subgroup analysis of stroke acuity, unilateral or bilateral leg movement, and control intervention (sham mirror therapy or conventional physiotherapy), if subgroups were comprised of 2 or more studies. Otherwise, single study was removed as a sensitivity analysis if there was a clinical or methodological difference from the other studies in the analysis. For example, if only 1 study in the overall analysis compared mirror therapy to conventional therapy (and not sham mirror therapy), a sensitivity analysis was performed by removing that single study.

Forest plots were generated to display the contribution of each study to the pooled effect. A separate meta-analysis was performed for studies which combined mirror therapy with supplemental stimulation. Authors were contacted via email for unreported data; if no response was received, missing data were imputed. For gait speed and balance, missing standard deviations of change values[25-30] were imputed using correlation coefficients calculated from other studies included in the meta-analyses,[31,32] following the method described in the Cochrane Handbook.[22] Missing standard deviations of change values for Ji[33] were calculated from the CIs provided. For motor recovery and mobility, missing standard deviations were not imputed as the calculated correlation coefficients from other studies[32,34] was below .5 (as instructed in the Cochrane Handbook). Instead, the standard deviation from the baseline measure was substituted to perform the meta-analysis of change scores. Risk of publication bias was not assessed by visual inspection of funnel plots as the current meta-analyses did not include 10 studies or more.[22] Instead, individual studies were inspected for reporting of nonsignificant comparisons to suggest reduced risk of selective reporting.

Results

A total of 179 articles were retrieved from the PubMed, Embase, MEDLINE, Cochrane Central Register of Controlled Trials, Cumulative Index to Nursing and Allied Health Literature, Physiotherapy Evidence Database, and

PsychINFO. Two articles were identified from hand-searching reference lists of relevant reviews. Seventeen studies met the inclusion criteria to be included in this systematic review (Fig 1).

Study Characteristics and Stroke Population

A total of 633 participants were included across all of the studies. The mean age of participants ranged from 44.5 (6.1) to 69.6 (12.2) (Table 1). The mean timing of intervention was between 5.7 (3.5) days and 42.5 (33.9) months after stroke (47% chronic stroke). Both male and female participants were included in all studies, as well as ischemic and hemorrhagic strokes. Participants were ambulatory without requiring physical assistance in 10 studies.[26-33,35,36] Otherwise, participants were required to demonstrate

some lower extremity function in 6 studies[25,34,37-40]; only in 1 study were participants eligible with lower extremity flaccid paralysis.[41] Five studies included additional treatment arms which varied from supplemental stimulation[26,32,37] to weighted mirror therapy[39] to action-observation training with activity.[29] Five studies included supplemental stimulation in combination with mirror therapy; 3 utilized neuromuscular electrical stimulation (NMES)[26,27,32] and 2 utilized repetitive transcranial magnetic stimulation.[30,35]

Risk of bias for each study, assessed using the Cochrane Collaboration's tool, is displayed in Figure 2. Given the nature of physiotherapy interventions, no studies blinded subjects or therapists. As can be seen in Figure 2, only a handful of studies were rated to have a low risk of bias in all other domains.[25,32,34] All trials randomly allocated
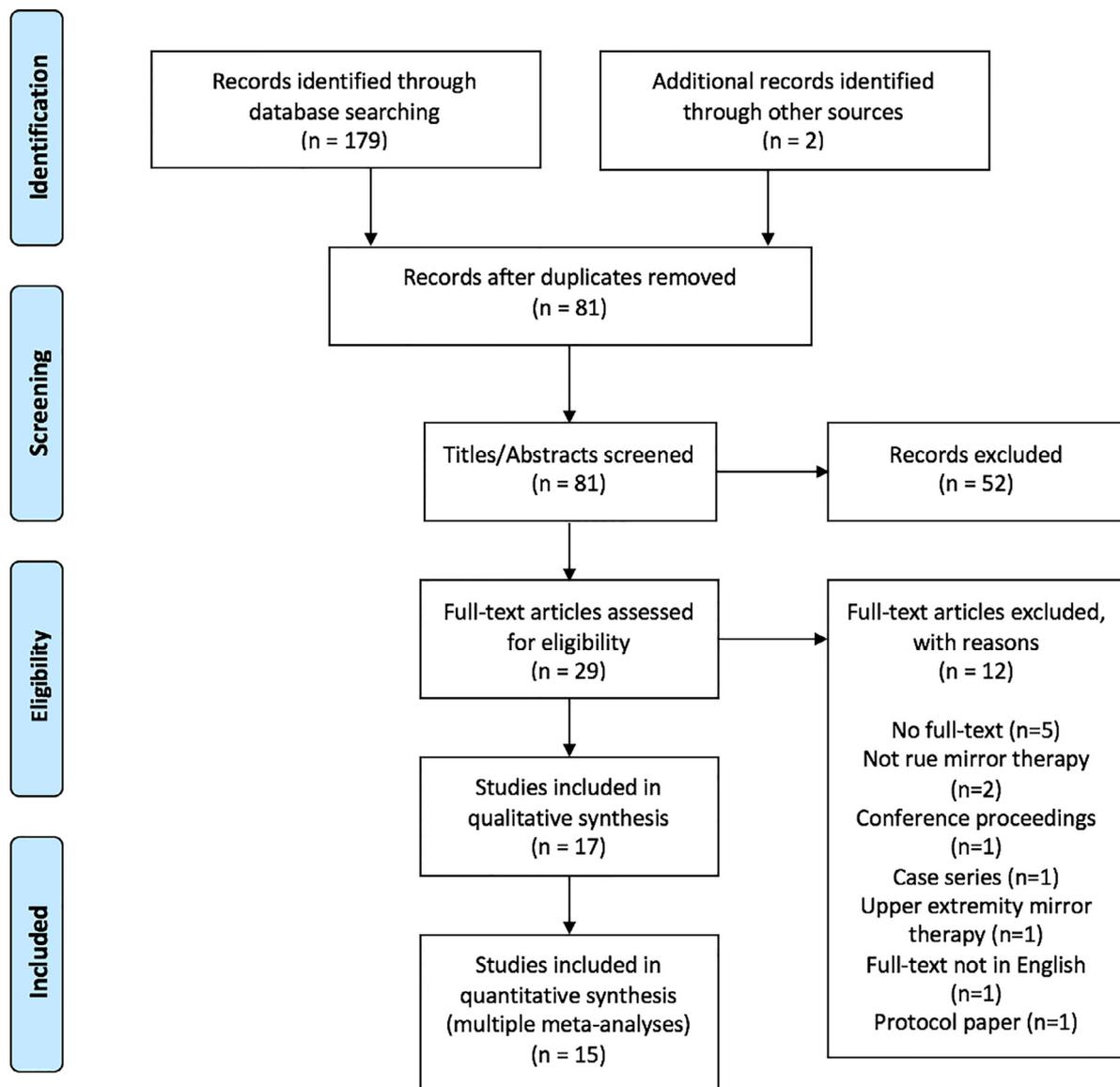

Figure 1. *Flow diagram of search and selection of articles.*

Table 1. *Characteristics of included studies in this review*

Study	N (male)	Mean age, y (SD)	Time since stroke (SD)	Intervention length/ frequency	Mirror therapy (MT) intervention	Control intervention
Kim et al, 2018[39]	MT: 10 (?) Control: 10 (?) MT + weight: 10 (?)	MT: 69.6 (12.24) Control: 62.1 (9.52) MT + weight: 72.3 (11.35)	Chronic stroke MT: N/A Control: N/A MT + weight: N/A	30 repetitions × 5 sets, 5 days a week, 4 weeks	MT performed seated knee extension and flexion MT + weight: performed above exercise except with an ankle weight (non-paretic side only)	Sham MT (no mirror)
Arya et al, 2017[25]	MT: 19 (15) Control: 17 (15)	MT: 48.16 (8.36) Control: 44.53 (6.09)	Chronic stroke MT: 13.74 (9.45) mo Control: 18.29 (8.08) mo	60 min, 3-4 days a week, 12 weeks (up to 30 sessions)	30 min MT task-based training using whole LE (non-paretic side only) Conventional motor therapy (30 min)	60 min Conventional motor therapy
De et al, 2017[36]	MT: 15 (?) Control: 15 (?)	MT: N/A Control: N/A	Subacute/chronic stroke MT: N/A Control: N/A	60 min, 5 days a week, 4 weeks	30 min MT movement training at ankle (non-paretic side only) 30 min conventional therapy	30 min mental imagery 30 min conventional therapy
Lee et al, 2017[29]	MT: 11 (?) Control: 12 (?) AOTA: 12 (?)	MT: 57.27 (5.7) Control: 59.8 (6.7) AOTA: 62.8 (7.4)	Chronic stroke MT: N/A Control: N/A AOTA: N/A	30 min, 3 days a week, 6 weeks	15 min MT movement training at hip, knee, ankle (non-paretic side only) 15 min movement practice without mirror AOTA group: (15 min action observation training, 15 min movement practice)	30 min action observation training (no movement)
Wang et al, 2017[41]	MT: 18 (13) Control: 18 (12)	MT: 52.45 (2.91) Control: 53.00 (2.79)	Subacute stroke MT: <2 mo Control: <2 mo	40 min, 5 days a week, 6 weeks	40 min MT movement and training at hip, knee, ankle (bilateral practice)	40 min sham MT
Xu et al, 2017[32]	MT: 23 (16) Control: 23 (15) MT + NMES: 23 (16)	MT:53.7 (8.98) Control: 56.09 (8.12) MT + NMES: 55.0 (10.98)	Subacute stroke MT: 42.76 (5.65) d Control: 45.78 (6.5) d MT + NMES: 43.25 (5.95) d	30 min, 5 days a week, 4 weeks	30 min MT movement training at ankle (+/- NMES) (bilateral practice)	30 min sham MT
In et al, 2016[31]	MT: 13 (8) Control: 12 (7)	MT: 57.31 (10.53) Control: 54.42 (11.44)	Chronic stroke MT: 12.54 (4.14) mo Control: 13.58 (5.28) mo	60 min, 5 days a week, 4 weeks	30 min MT movement and task-based training of whole LE (bilateral practice) 30 min conventional therapy	30 min sham MT 30 min conventional therapy
Kim et al, 2016[38]	MT: 17 (8) Control: 17 (7)	MT: 52.4 (7.2) Control: 54.6 (10.2)	Subacute stroke MT: 4.7 (1.3) mo Control: 4.5 (1.1) mo	60 min, 5 days a week, 4 weeks	30 min MT movement training at hip, knee, ankle + standing balance training (non-paretic side only) 30 min conventional PT	30 min sham MT + standing balance training 30 min conventional PT

Table 1 (*Continued*)

Study	N (male)	Mean age, y (SD)	Time since stroke (SD)	Intervention length/ frequency	Mirror therapy (MT) intervention	Control intervention
Lee et al, 2016[27]	MT + NMES: 14 (7) Control: 13 (7)	MT: 55.71 (6.7) Control: 53.62 (6.29)	Chronic stroke MT: 36.79 (26.07) mo Control: 42.54 (33.9) mo	60 min, 5 days a week, 4 weeks	MT + NMES once daily (bilateral practice) 60 min conventional therapy	60 min conventional therapy
Cha et al, 2015a[30]	MT + rTMS: 19 (10) Control: 17[9]	MT: 60.00 (7.80) Control: 57.35 (9.38)	Subacute stroke MT: 1.95 (.62) mo Control: 1.65 (.86) mo	40 min, 5 days a week, 4 weeks	20 min rTMS 20 min MT movement training at hip, knee, ankle (non-paretic side only)	20 min rTMS 20 min sham MT
Cha et al, 2015b[35]	MT +rTMS: 15 (7) Control: 15 (6)	MT + rTMS: 59.43 (13.0) Control: 62.0 (12.0)	Chronic stroke MT + rTMS: 14.45 (3.14) mo Control: 14.14 (1.55) mo	40 min, 5 days a week, 4 weeks	20 min rTMS 20 min MT movement training at hip, knee, ankle (non-paretic side only)	20 min rTMS 20 min sham MT
Ji et al, 2015[33]	MT: 17 (9) Control: 17 (10)	MT: 55.2 (7.5) Control: 54.3 (8.7)	Subacute stroke MT: 4.3 (1.5) mo Control: 4.5 (1.3) mo	45 min, 5 days a week, 4 weeks	15 min MT movement practice at hip, knee, ankle (non-paretic side only) 30 min conventional therapy	15 min sham MT 30 min conventional therapy
Kawakami et al, 2015[37]	MT: 16 (11) Control: 8 (5) Other: 43 (27)	MT: 61.6 (12.7) Control: 65.6 (15.9) Other: N/A	Subacute stroke MT: 37.9 (11.8) d Control: 38.9 (14.8) d Other: N/A	60 min, 5 days a week, 4 weeks	60 min MT movement practice at hip, knee, ankle (bilateral practice) Other: integrated volitional-control stimulation, NMES, facilitated exercises	60 min conventional therapy
Salem et al, 2015[28]	MT: 15 (8) Control: 15 (7)	MT: 60 (8.97) Control: 59.1 (9.1)	Chronic stroke MT: 14.9 (1.83) mo Control: 15.4 (1.28) mo	30 min, 5 days a week, 4 weeks	MT movement training at hip, knee, ankle (bilateral practice)	Sham MT (non-reflective side)
Ji et al, 2014[26]	MT: 10 (7) Control: 10 (6) MT + NMES: 10 (6)	MT: 48.6 (8.5) Control: 54.6 (9.2) MT + NMES: 52.9 (9.9)	Subacute/chronic stroke MT: 7.3 (2.9) mo Control: 6.7 (2.3) mo MT + NMES: 7.1 (3.4) mo	50 min, 5 days a week, 6 weeks	20 min MT movement training at ankle (+/- NMES) (bilateral practice) 30 min conventional therapy	20 min sham MT 30 min conventional therapy
Mohan et al, 2013[40]	MT: 11 (4) Control: 11 (8)	MT: 62.64 (17.3) Control: 59.8 (6.7)	Acute stroke MT: 7.09 (3.18) d Control: 5.73 (3.47) d	30 min, 6 days a week, 2 weeks	30 min MT movement training at hip, knee, ankle (non-paretic side only)	30 min sham MT
Sütbeyaz et al, 2007[34]	MT: 20 (10) Control: 20 (13)	MT: 62.7 (9.7) Control: 64.7 (7.7)	Subacute stroke MT: 3.5 (1.3) mo Control: 3.9 (1.9) mo	30 min, 5 days a week, 4 weeks	30 min MT movement training at ankle (non-paretic side only)	30 min sham MT

AOTA: action observation training with activity; mo: month; MT: mirror therapy; NMES: neuromuscular electrical stimulation; rTMS: repetitive transcranial magnetic stimulation; SD: standard deviation; y: year.

Figure 2. *Risk of bias summary: review authors' judgements about each risk of bias item for included studies.*

included participants, but the nature of randomization and allocation concealment was not adequately detailed in many of the studies. Similarly, there was inadequate information to determine the risk of reporting bias in a majority of the studies. Several studies were highlighted for risk of other biases; for example, there was a significant difference in baseline stroke impairment between the mirror therapy and control group in Mohan et al's[40] study despite randomization. Further details regarding the risk of bias assessment can be found in Appendix 2. Among the 17 included studies, 6 reported significant improvement in favour of mirror therapy in all measured outcomes.[26,31,32,35,38,41] This could indicate a degree of publication bias among the research trials surrounding lower extremity mirror therapy.

Intervention Dose and Content

There was wide variety in the frequency and duration of intervention between studies. Mirror therapy was provided for 15-40 minutes, 3-6 days a week for 2- 12 weeks, adding up to a total of 12-30 sessions (Table 1). In 3 trials,[30,35,39] mirror therapy was the sole therapy provided to participants in the intervention group; otherwise mirror therapy was provided in addition to standard inpatient stroke rehabilitation or coupled with 30-60 minutes of conventional physical therapy. The time dose of therapy in the mirror therapy and control groups was matched in all but 1 trial,[27] wherein mirror therapy and NMES were provided daily (duration unknown) to the experimental group in addition to the 60 minutes of conventional physical therapy provided to both experimental and control groups.

The content of the mirror therapy was fairly similar between trials, positioning subjects in sitting (upright sitting, semi-seated, and long-sitting) with a mirror between the legs so that the reflection of the nonparetic lower limb replaced the view of the paretic lower limb. One study utilized a "virtual" set-up, consisting of a video image of the nonparetic leg projected onto a screen above the paretic leg, to allow for a symmetrical, up-right trunk position.[31] Participants performed various movements with the nonparetic limb to visually simulate movement of the paretic side. Participants in 5 studies[26,27,32,34,36] performed only ankle movements during mirror therapy; participants in another study only performed knee extension and flexion during mirror therapy.[39] The remaining 11 studies combined hip, knee, and ankle movements in the mirror image. In 10 studies, participants moved only the nonparetic leg, while in the other 7 studies participants were asked to attempt bilateral movement. One study included standing balance training in front of a mirror within their mirror therapy intervention.[38] In the 3 studies that utilized NMES with mirror therapy,[26,27,32] the stimulation was placed and set to elicit dorsiflexion (±eversion) of the paretic ankle. In the 2 studies that utilized repetitive transcranial magnetic stimulation, an excitatory stimulation was used over the ipsilesional motor cortex.

The control interventions consisted of matched-time sham mirror therapy (switched mirror orientation to

Table 2. *Reported outcomes and findings of included studies*

Study	Outcome measures of motor function	Significant between-group findings of motor function*	Outcome measures of balance	Significant between-group findings of balance*	Outcome measures of gait and mobility	Significant between-group findings of gait*
Kim et al, 2018[39]	Knee extensor and flexor muscle strength	Not significant	-	-	-	-
Arya et al, 2017[25]	Brunnstrom Stage, FMA-Lower	FMA	-	-	Rivermead visual gait assessment, 10MWT	Rivermead visual gait assessment
De et al, 2017[36]	MAS, FMA-Lower	FMA-Lower (+mental imagery)	-	-	10MWT	Not significant
Lee et al, 2017[29]	-	-	Balance index	Not significant	Modified Emory functional ambulation profile	Not significant
Wang et al, 2017[41]	Brunnstrom Stage	Brunnstrom Stage	BBS	Not significant/unclear	FAC, FIM (transfers and walking components)	FAC, FIM (transfers and walking components)
Xu et al, 2017[32]	Brunnstrom Stage, MAS, passive DF ROM	Brunnstrom Stage (+MT, +MT NMES), MAS (+MT NMES), DF ROM (+MT, +MT NMES)	-	-	10MWT	10MWT (+MT, +MT NMES)
In et al, 2016[31]	-	-	BBS, FRT, static balance (sway)	BBS, FRT, eyes open static balance	10MWT, TUG	10MWT, TUG
Kim et al, 2016[38]	-	-	Balance index (Sway)	Balance index	-	-
Lee et al, 2016[27]	Dorsiflexor strength, MAS	Dorsiflexor strength (+MT NMES)	BBS	BBS (+MT NMES)	TUG, gait speed	Not significant
Cha et al, 2015a[30]	-	-	Balance index, Dynamic Limits of Stability, BBS	BI, DLOS	TUG	TUG
Cha et al, 2015b[35]	-	-	-	-	Temporospatial features of gait (e.g gait speed, stride length)	Gait speed

Stride length

Step length |
| Ji et al, 2015[33] | - | - | - | - | Temporospatial features of gait | Stride length

Step length |
| Kawakami et al, 2015[37] | SIAS | Not significant | - | - | - | - |

Table 2 (*Continued*)

Study	Outcome measures of motor function	Significant between-group findings of motor function*	Outcome measures of balance	Significant between-group findings of balance*	Outcome measures of gait and mobility	Significant between-group findings of gait*
Salem et al, 2015[28]	Passive DF ROM, MAS, Brunnstrom Stage	Not reported	-	-	10MWT	Not reported
Ji et al, 2014[26]	-	-	-	-	Temporospatial features of gait	Gait speed (+MT NMES, +MT) Stride length (+MT NMES) Step length (+MT NMES)
Mohan et al, 2013[40]	FMA-Lower, Brunnstrom Stage	Not significant	Brunnel Balance Assessment	Not significant	FAC	FAC
Sütbeyaz et al, 2007[34]	Brunnstrom Stage, MAS, FIM motor (6 months)	Brunnstrom Stage, FIM	-	-	FAC (6 months)	Not significant

10MWT: 10-Meter walk test; BBS: berg balance scale; DF: dorsiflexion; DLOS: dynamic limits of stability; FAC: functional ambulation category; FIM: functional independence measure; FMA-Lower: Fugl-Meyer assessment of the lower extremity; FRT: functional reach test; MAS: modified Ashworth scale; MT: mirror therapy; MT NMES: mirror therapy with neuromuscular electrical stimulation; ROM: range of motion; TUG: timed up and go.
*Unless otherwise indicated, all significant between-group findings are in favour of mirror therapy.

nonreflective side or covered reflective surface) in 12 studies.[26,28,40,41,30-35,38,39] In 3 studies, the control group received individualized conventional physiotherapy.[25,27,37] One study compared mirror therapy to mental imagery,[36] while another study compared mirror therapy to action observation training.[29]

Efficacy of Mirror Therapy

Gait Speed

Nine studies included measures of gait speed,[25-28,31-33,35,36] of which 4 studies reported a significant between-group difference showing greater improvement in favour of mirror therapy[26,31,32,35] (Table 2). Further examination by pooling the available data from 6 studies, which compared mirror therapy (without supplemental stimulation) to control, showed a large effect of mirror therapy on gait speed (SMD = 1.04 [95% CI = .43, 1.66], I^2 = 73%, and $P < .001$; Fig 3a). Removing 1 study which utilized a conventional physiotherapy control,[25] the effect of mirror therapy compared to sham mirror therapy was larger (SMD = 1.24 [95% CI = .63, 1.85] I^2 = 64%, and $P < .001$). Subgroup analysis explored the heterogeneity of the effect of mirror therapy on gait speed by acuity of stroke (subacute stroke [3 studies]: SMD = 1.36 [95% CI = .31, 2.40], I^2 = 79%, and $P = .01$; chronic stroke [3 studies]: SMD = .77 [95% CI = −.03, 1.58] I^2 = 70%, and $P = .06$) (Fig 3b) and sidedness of movement (unilateral [2 studies]: SMD = .25 [95% CI = −.23, .73], I^2 = 0%, and $P = .31$; bilateral [4 studies]: SMD = 1.45 [95% CI = .85, 2.05], I^2 = 50%, and $P < .001$; Fig 3c). Data from 4 studies which combined mirror therapy with supplemental stimulation were pooled together and showed a substantial effect on gait speed improvement (SMD = 1.58 [95% CI = .60, 2.56], I^2 = 80%, and $P = .002$) (Fig 4).

Mobility

Seven studies reported on mobility,[27,29-31,34,40,41] including measures of walking independence, movement tasks, and transfers. Three studies[31,40,41] reported a significant between-group outcome in favour of mirror therapy. Pooled analysis of 5 studies with available data showed a small effect of mirror therapy on mobility outcomes compared with sham therapy (SMD = .46 [95% CI = .01, .90], I^2 = 43%, and $P = .05$; Fig 5). Subgroup analysis of acuity did not yield a significant effect in either subacute or chronic stroke (Appendix 3). On the other hand, subgroup analysis of sidedness of movement favoured bilateral training (unilateral [3 studies]: SMD = .27 [95% CI = −.41, .96], I^2 = 57%, and $P = .43$; bilateral [2 studies]: SMD = .73 [95% CI = .21, 1.25], I^2 = 0%, and $P = .006$) (Appendix 3). Two studies combining mirror therapy with supplemental stimulation reported on mobility outcomes[27,30]; pooling this data did not yield a significant effect (SMD = .57 [95% CI = −.11, 1.25], I^2 = 43%, and $P = .10$) (Appendix 3).

(a)

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Arya et al, 2017	0.06	0.13	19	0.03	0.37	17	18.6%	0.11 [−0.55, 0.76]
In et al, 2016	0.11	0.06	13	0.02	0.05	12	15.5%	1.57 [0.65, 2.49]
Ji et al, 2014	15.2	3.8	10	6.8	2.3	10	12.0%	2.56 [1.32, 3.81]
Ji et al, 2015	16.8	20.9	16	9.5	11.7	15	17.9%	0.42 [−0.30, 1.13]
Salem et al, 2015	0.08	0.14	15	−0.03	0.13	15	17.5%	0.79 [0.04, 1.54]
Xu et al, 2017	7.21	2.72	23	3.55	2.41	23	18.6%	1.40 [0.75, 2.05]
Total (95% CI)			96			92	100.0%	1.04 [0.43, 1.66]

Heterogeneity: Tau² = 0.42; Chi² = 18.61, df = 5 (P = 0.002); I² = 73%
Test for overall effect: Z = 3.31 (P = 0.0009)

(b)

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.2.1 Subacute								
Ji et al, 2014	15.2	3.8	10	6.8	2.3	10	12.0%	2.56 [1.32, 3.81]
Ji et al, 2015	16.8	20.9	16	9.5	11.7	15	17.9%	0.42 [−0.30, 1.13]
Xu et al, 2017	7.21	2.72	23	3.55	2.41	23	18.6%	1.40 [0.75, 2.05]
Subtotal (95% CI)			49			48	48.5%	1.36 [0.31, 2.40]

Heterogeneity: Tau² = 0.66; Chi² = 9.56, df = 2 (P = 0.008); I² = 79%
Test for overall effect: Z = 2.54 (P = 0.01)

1.2.2 Chronic								
Arya et al, 2017	0.06	0.13	19	0.03	0.37	17	18.6%	0.11 [−0.55, 0.76]
In et al, 2016	0.11	0.06	13	0.02	0.05	12	15.5%	1.57 [0.65, 2.49]
Salem et al, 2015	0.08	0.14	15	−0.03	0.13	15	17.5%	0.79 [0.04, 1.54]
Subtotal (95% CI)			47			44	51.5%	0.77 [−0.03, 1.58]

Heterogeneity: Tau² = 0.35; Chi² = 6.63, df = 2 (P = 0.04); I² = 70%
Test for overall effect: Z = 1.88 (P = 0.06)

Total (95% CI)			96			92	100.0%	1.04 [0.43, 1.66]

Heterogeneity: Tau² = 0.42; Chi² = 18.61, df = 5 (P = 0.002); I² = 73%
Test for overall effect: Z = 3.31 (P = 0.0009)
Test for subgroup differences: Chi² = 0.75, df = 1 (P = 0.39), I² = 0%

(c)

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
1.3.1 Unilateral movements								
Arya et al, 2017	0.06	0.13	19	0.03	0.37	17	18.6%	0.11 [−0.55, 0.76]
Ji et al, 2015	16.8	20.9	16	9.5	11.7	15	17.9%	0.42 [−0.30, 1.13]
Subtotal (95% CI)			35			32	36.4%	0.25 [−0.23, 0.73]

Heterogeneity: Tau² = 0.00; Chi² = 0.39, df = 1 (P = 0.53); I² = 0%
Test for overall effect: Z = 1.01 (P = 0.31)

1.3.2 Bilateral movements								
In et al, 2016	0.11	0.06	13	0.02	0.05	12	15.5%	1.57 [0.65, 2.49]
Ji et al, 2014	15.2	3.8	10	6.8	2.3	10	12.0%	2.56 [1.32, 3.81]
Salem et al, 2015	0.08	0.14	15	−0.03	0.13	15	17.5%	0.79 [0.04, 1.54]
Xu et al, 2017	7.21	2.72	23	3.55	2.41	23	18.6%	1.40 [0.75, 2.05]
Subtotal (95% CI)			61			60	63.6%	1.45 [0.85, 2.05]

Heterogeneity: Tau² = 0.19; Chi² = 6.00, df = 3 (P = 0.11); I² = 50%
Test for overall effect: Z = 4.72 (P < 0.00001)

Total (95% CI)			96			92	100.0%	1.04 [0.43, 1.66]

Heterogeneity: Tau² = 0.42; Chi² = 18.61, df = 5 (P = 0.002); I² = 73%
Test for overall effect: Z = 3.31 (P = 0.0009)
Test for subgroup differences: Chi² = 9.33, df = 1 (P = 0.002), I² = 89.3%
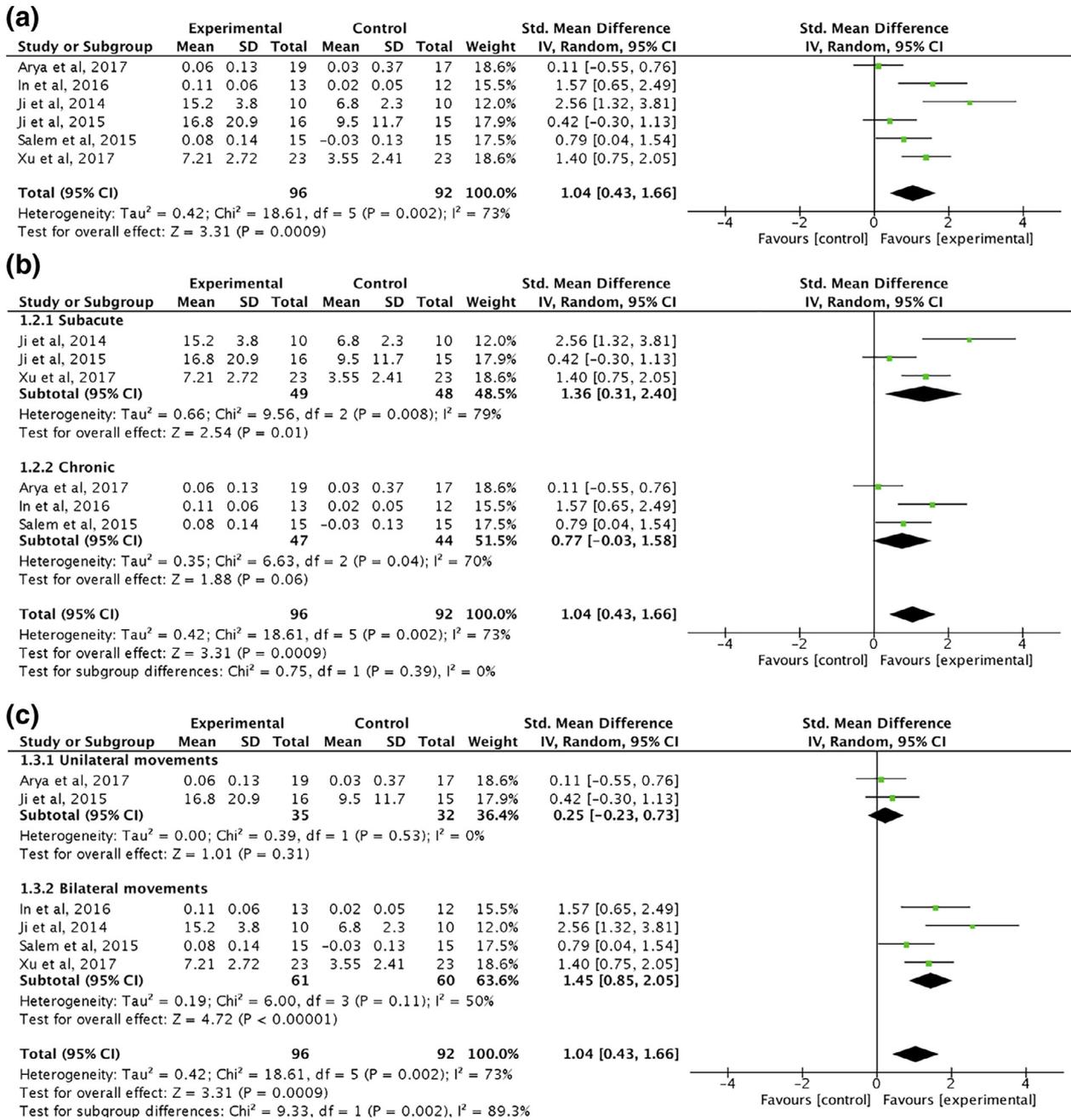
Figure 3. *Forest plot of the effect of mirror therapy on gait speed (a) and subgroup analysis based on (b) stroke acuity and (c) sidedness of training.*
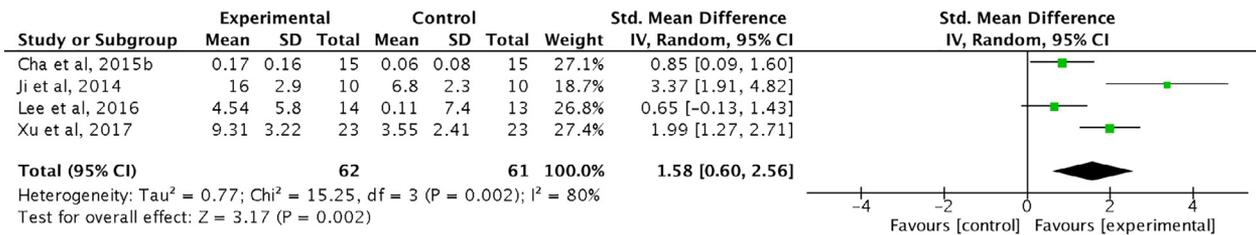
Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Cha et al, 2015b	0.17	0.16	15	0.06	0.08	15	27.1%	0.85 [0.09, 1.60]
Ji et al, 2014	16	2.9	10	6.8	2.3	10	18.7%	3.37 [1.91, 4.82]
Lee et al, 2016	4.54	5.8	14	0.11	7.4	13	26.8%	0.65 [−0.13, 1.43]
Xu et al, 2017	9.31	3.22	23	3.55	2.41	23	27.4%	1.99 [1.27, 2.71]
Total (95% CI)			62			61	100.0%	1.58 [0.60, 2.56]

Heterogeneity: Tau² = 0.77; Chi² = 15.25, df = 3 (P = 0.002); I² = 80%
Test for overall effect: Z = 3.17 (P = 0.002)

Figure 4. *Forest plot of the effect of mirror therapy with supplemental stimulation on gait speed.*

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
In et al, 2016	3.8	3.72	13	1.09	2.23	12	18.1%	0.85 [0.02, 1.67]
Lee et al, 2017	14	17.1	11	16.7	25.2	12	18.3%	-0.12 [-0.94, 0.70]
Mohan et al, 2013	1.55	0.52	11	0.82	0.75	11	16.0%	1.09 [0.18, 2.00]
Sütbeyaz et al, 2007	0.9	0.5	20	0.9	0.7	20	24.7%	0.00 [-0.62, 0.62]
Wang et al, 2017	1.28	0.96	18	0.61	1.04	18	22.8%	0.65 [-0.02, 1.33]
Total (95% CI)			**73**			**73**	**100.0%**	**0.46 [0.01, 0.90]**

Heterogeneity: Tau² = 0.11; Chi² = 7.00, df = 4 (P = 0.14); I² = 43%
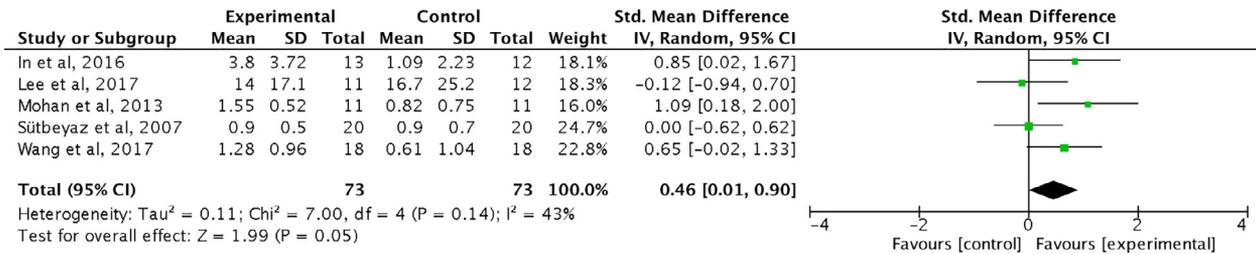Test for overall effect: Z = 1.99 (P = 0.05)

Figure 5. *Forest plot of the effect of mirror therapy on mobility.*

Balance

Six of the included studies measured balance performance, 2 of which observed static postural sway[29,38], 3 of which assessed functional balance tasks using the Berg Balance Scale or Brunnel Balance Assessment,[27,31,40] and 1 which measured both.[30] Four studies reported significant between-group improvements in favour of mirror therapy.[27,30,31,38] Pooled analysis of 4 studies with available data did not show a significant improvement in balance after mirror therapy alone when compared to sham therapy (SMD = .69 [95% CI = −.08, 1.46], I² = 71%, and P = .08) (Fig 6). Removing 1 study[31] in chronic stroke and bilateral movement did not change the direction or significance of the pooled analysis for subacute stroke performing unilateral mirror therapy training (SMD = .51 [95% CI = −.46, 1.48], I² = 77%, and P = .30) (Appendix 4). However, pooled analysis of the two studies combining mirror therapy with stimulation[27,30] showed a significant and large positive effect on balance (SMD = 1.14 [95% CI = .60, 1.68], I² = 0%, and P < .001; Appendix 4).

Motor Function

Ten of the 17 studies included in this review measured change in motor function with mirror therapy. Eight of those studies included a measure of motor recovery (eg, Fugl-Meyer Assessment [FMA], Stroke Impairment Assessment Set [SIAS], and Brunnstrom stage),[25,28,32,34,36,37,40,41] while 2 studies only measured muscle strength at the knee[39] or ankle.[27] Pooled analysis of 7 studies with available data on stroke motor recovery revealed a small effect of mirror therapy (SMD = .47 [95% CI = .21, .74], I² = 0%, and P < .001; Fig 7). Subgroup analysis explored the effect of acuity of stroke (subacute [5 studies]: SMD = .50

[95% CI = .19, .81], I² = 0%, and P = .002; chronic [2 studies]: SMD = .40 [95% CI = −.09, .89], I² = 0%, and P = .11), sidedness of movement (unilateral [3 studies]: SMD = .46 [95% CI = .06, .86], I² = 0%, and P = .03; bilateral [4 studies]: SMD = .48 [95% CI = .14, .83], I² = 0%, and P = .006), and control intervention (sham mirror therapy [5 studies]: SMD = .53 [95% CI = .22, .83], I² = 0%, and p < .001; conventional physiotherapy [2 studies]: SMD = .32 [95% CI = −.21, .84], I² = 0%, and P = .23) (Appendix 5). Only 1 study[32] combining mirror therapy with neuromuscular electric stimulation reported a significantly greater change in Brunnstrom Stage than control but no different than when mirror therapy was performed without stimulation (Appendix 5).

Adverse Events

Only 6 studies reported on adverse events and reason for study drop-out. Of these, 4 studies reported no adverse events associated with the mirror therapy intervention or control.[25,32,34,40] Two studies reported adverse events which led to participant drop-outs, equally distributed between the intervention and control groups. The primary reason for study drop-out in 1 study was dizziness.[31] Unrelated hip fracture due to a fall led to a participant drop-out in both the experimental and control group in another study.[27] Eleven studies did not mention whether adverse events occurred or not.

Discussion

A majority of the 17 studies included in this review reported positive outcomes after mirror therapy of the lower extremity. Pooled effect estimates showed a
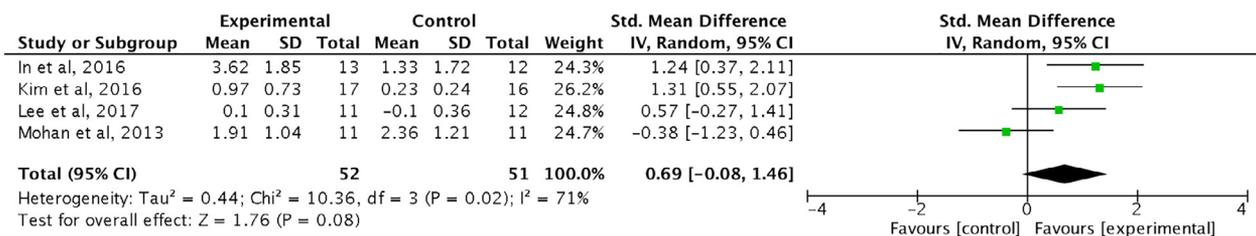
Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
In et al, 2016	3.62	1.85	13	1.33	1.72	12	24.3%	1.24 [0.37, 2.11]
Kim et al, 2016	0.97	0.73	17	0.23	0.24	16	26.2%	1.31 [0.55, 2.07]
Lee et al, 2017	0.1	0.31	11	-0.1	0.36	12	24.8%	0.57 [-0.27, 1.41]
Mohan et al, 2013	1.91	1.04	11	2.36	1.21	11	24.7%	-0.38 [-1.23, 0.46]
Total (95% CI)			**52**			**51**	**100.0%**	**0.69 [-0.08, 1.46]**

Heterogeneity: Tau² = 0.44; Chi² = 10.36, df = 3 (P = 0.02); I² = 71%
Test for overall effect: Z = 1.76 (P = 0.08)

Figure 6. *Forest plot of the effect of mirror therapy on balance capacity.*

Study or Subgroup	Experimental Mean	SD	Total	Control Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Arya et al, 2017	3.87	6.03	19	0.35	7.38	17	15.6%	0.51 [−0.15, 1.18]
Kawakami et al, 2015	1	3.3	16	1	3.9	8	9.6%	0.00 [−0.85, 0.85]
Mohan et al, 2013	6	3	11	6	2.24	11	9.9%	0.00 [−0.84, 0.84]
Salem et al, 2015	0.69	1.21	15	0.36	1.15	15	13.4%	0.27 [−0.45, 0.99]
Sütbeyaz et al, 2007	1.1	0.7	20	0.5	1	20	16.9%	0.68 [0.04, 1.32]
Wang et al, 2017	1.94	1.1	18	1.06	1.14	18	15.0%	0.77 [0.09, 1.45]
Xu et al, 2017	1	0.67	23	0.48	0.9	23	19.6%	0.64 [0.05, 1.24]
Total (95% CI)			**122**			**112**	**100.0%**	**0.47 [0.21, 0.74]**

Heterogeneity: Tau² = 0.00; Chi² = 4.19, df = 6 (P = 0.65); I² = 0%
Test for overall effect: Z = 3.53 (P = 0.0004)

Figure 7. *Forest plot of the effect of mirror therapy on motor recovery.*

significant improvement in gait speed, mobility, and motor recovery with lower extremity mirror therapy in stroke; however, there was not a significant pooled effect for balance. Subgroup analyses explored the heterogeneity of the included studies and highlighted that mirror therapy is more likely to have an effect: in subacute stroke patients; if performed using bilateral movement while still viewing the unaffected limb in the reflection; and when compared to sham therapy. Coupling lower extremity mirror therapy with supplemental stimulation (TMS or NMES) for ambulatory individuals with stroke showed a large positive effect for gait speed and balance compared to a control intervention.

Despite subgroup analyses which explored differences in the studies contributing to heterogeneity, there was still high variability in the intervention protocols of the included trials. As a result, the optimal mirror therapy dose to obtain motor and functional improvement is unclear. Some interventions required participants to achieve a certain number of repetitions (eg, 30 reps for 5 sets),[39] while others allotted a specific duration of mirror therapy per session. However, nearly half of the studies stated utilization of a modified protocol from Sütbeyaz et al'[34] seminal RCT in lower extremity mirror therapy after stroke, of 30 minutes a day, 5 days a week, for 4 weeks. As such, this dose may be a potential starting point for future research or clinical implementation.

In the majority of studies included in this review, mirror therapy was provided with additional conventional therapy within the experimental intervention, or as an adjunct therapy during inpatient stroke rehabilitation (which includes conventional physiotherapy). Only 1 study[37] replaced conventional inpatient therapy with mirror therapy for the experimental group; they did not find any significant between group differences in their sole measure of stroke impairment. In reviews of upper extremity mirror therapy after stroke, high heterogeneity between intervention groups made it unclear whether upper extremity mirror therapy should replace conventional therapy or should be used as an adjunct therapy.[16] In this review, we explored the effect of mirror therapy when compared with sham mirror therapy or with conventional therapy. It was found that mirror therapy is more effective than sham mirror therapy for gait speed

and motor recovery, but not when compared with conventional physiotherapy. This suggests that mirror therapy should not replace conventional physiotherapy but may be a positive adjunctive therapy to be pursued outside of one-on-one therapy. Our subgroup analysis also suggests that movement should be practiced bilaterally, despite vision of only the nonparetic leg and its reflection.

There were positive outcomes reported in studies investigating subacute and chronic stroke patients. Our subgroup analysis found a greater and significant effect in subacute stroke for gait speed and motor recovery. Only 1 study in this review enrolled participants within several days of the stroke,[40] which found significant improvement in walking dependence with mirror therapy compared to sham therapy in the first week after stroke, despite no between-group difference in motor impairment improvement. However, there were differences in baseline comparability between groups.

With regard to supplemental stimulation, it has been previously reported that NMES combined with or without other interventions has beneficial effects in lower limb motor function in chronic stroke survivors,[42] including gait speed and balance. Despite the large effect for gait speed and balance found in our analyses when combining mirror therapy with supplemental stimulation compared to control, it is unclear whether the mirror therapy was a key component for lower extremity improvement. There was insufficient data to compare mirror therapy with stimulation to mirror therapy alone in a meta-analysis; of the 2 studies which had 3 treatment arms (mirror therapy, mirror therapy with stimulation, and sham therapy), one reported no difference between the 2 mirror therapy arms[26] and the other reported a greater benefit combining NMES with mirror therapy.[32]

The findings from the present systematic review and meta-analysis are supported by 2 other recently published reviews,[20,21] which also found a significant effect of lower extremity mirror therapy for gait speed and motor recovery. However, the present review did not find a significant effect for balance, though there was evidence of a small effect for mobility; on the other hand, the 2 other reviews found a moderate effect for balance capacity but conflicting conclusions for mobility. This difference in findings may be explained by the method of analysis. Our

analysis compared the change from baseline between mirror therapy and control groups, which is considered more efficient and powerful,[22] while the other reviews compared final values between groups, which does not account for between-person variability.

The positive findings from this review have important implications for clinical practice. Mirror therapy is a safe therapy that can be performed in sitting, for both ambulatory and nonambulatory individuals with stroke. Given the simplicity of the modality, it has the potential to be carried out by rehabilitation assistants or even by stroke patients in their own homes, without direct supervision by a physiotherapist. It has been shown that balance impairments limit the ability to increase walking speed in individuals with chronic stroke,[43] and so a seated exercise that can improve balance may be an accessible method for patients to improve their walking without requiring supervision to perform walking practice itself. It is important to determine strategies to increase engagement and improve health after stroke, as stroke patients tend to be sedentary and only perform short bouts of walking after discharge from the hospital.[44] Interestingly, no studies have looked at stroke patients' experience of mirror therapy. In addition to efficacy, it is essential to determine both therapist and patient perception of mirror therapy before implementing this therapy widely for stroke survivors.

Limitations

This systematic review has several limitations. Given that all but one of the included studies reported either positive results or equivalence with control, it may suggest that studies with negative results were not as widely published. There is a chance that study authors reported only measures with significant findings, which may exaggerate the effectiveness of mirror therapy for the lower extremity after stroke. Second, not all studies measured motor impairment, balance, and gait; within those domains, there was heterogeneity in the specific outcome measures used. This limited the number of studies that were included in each pooled analysis. The long-term effects of mirror therapy were not analyzed in this review, as only 1 study reported long-term outcomes.[34]

Finally, analysis of the efficacy of mirror therapy with supplemental stimulation was limited by the number of studies in this area. We did not compare the effect of mirror therapy with supplemental stimulation to stimulation alone. Future research should investigate whether the benefit of mirror therapy with stimulation is unique to the combination of the two modalities, or if the improvement is derived from the stimulation or mirror therapy alone.

Conclusions

This review found that mirror therapy for the lower extremity, as well as mirror therapy supplemented with stimulation, has positive outcomes for improving gait speed. This review also found positive outcomes for motor recovery after stroke when mirror therapy is performed for the lower extremity. Current results also suggest that mirror therapy is more likely to have an effect for subacute stroke patients and when attempting to perform bilateral movements.

Authorship

Conceived idea for paper: D.R.L. Conducted review: D.R.L., S.B.L. Wrote the paper: D.R.L., S.B.L., and J.J.E.

Conflicts of Interest

The authors declare no conflicts of interest.

Supplementary Materials

Supplementary data to this article can be found online at doi:10.1016/j.jstrokecerebrovasdis.2018.09.017.

References

1. Katzan IL, Thompson NR, Uchino K, et al. The most affected health domains after ischemic stroke. Neurology 2018;90: e1364-e1371.
2. Hankey GJ. Stroke. Lancet 2016;6736:1-14.
3. Lopez AD, Mathers CD, Ezzati M, et al. Global and regional burden of disease and risk factors, 2001: systematic analysis of population health data. Lancet 2006;367:1747-1757.
4. Chan L, Sandel ME, Jette AM, et al. Does postacute care site matter? A longitudinal study assessing functional recovery after a stroke. Arch Phys Med Rehabil 2013;94:922-929.
5. Belgen B, Beninato M, Sullivan PE, et al. The association of balance capacity and falls self-efficacy with history of falling in community-dwelling people with chronic stroke. Arch Phys Med Rehabil 2006;87:554-561.
6. Brogårdh C, Flansbjer UB, Lexell J. Self-reported walking ability in persons with chronic stroke and the relationship with gait performance tests. PM R 2012;4:734-738.
7. Wesselhoff S, Hanke TA, Evans CC. Community mobility after stroke: a systematic review. Top Stroke Rehabil 2018;25:224-238.
8. Pang MY, Eng JJ, Miller WC. Determinants of satisfaction with community reintegration in older adults with chronic stroke: role of balance self-efficacy. Phys Ther 2007;87:282-291.
9. Cohen JW, Ivanova TD, Brouwer B, et al. Do performance measures of strength, balance, and mobility predict quality of life and community reintegration after troke? Arch Phys Med Rehabil 2018;99:713-719.
10. Krueger H, Koot J, Hall RE, et al. Prevalence of individuals experiencing the effects of stroke in Canada: trends and projections. Stroke 2015;46:2226-2231.
11. Kerr A, Dawson J, Robertson C, et al. Sit to stand activity during stroke rehabilitation. Top Stroke Rehabil 2017;24:562-566.
12. Fini NA, Holland AE, Keating J, et al. How physically active are people following stroke? Systematic review and quantitative synthesis. Phys Ther 2017;97:707-717.

13. Deconinck FJA, Smorenburg ARP, Benham A, et al. Reflections on mirror therapy: a systematic review of the effect of mirror visual feedback on the brain. Neurorehabil Neural Repair 2015;29:349-361.

14. Herrador Colmenero L, Perez Marmol JM, Martí-García C, et al. Effectiveness of mirror therapy, motor imagery, and virtual feedback on phantom limb pain following amputation: a systematic review. Prosthet Orthot Int 2018;42:288-298.

15. Zeng W, Guo Y, Wu G, et al. Mirror therapy for motor function of the upper extremity in patients with stroke: a meta-analysis. J Rehabil Med 2018;50:8-15.

16. Thieme H, Mehrholz J, Pohl M, et al. Mirror therapy for improving motor function after stroke. Stroke 2013;44: 2012-2014.

17. Pervane Vural S, Nakipoglu Yuzer GF, Sezgin Ozcan D, et al. Effects of mirror therapy in stroke patients with complex regional pain syndrome type 1: a randomized controlled study. Arch Phys Med Rehabil 2016;97:575-581.

18. Cacchio A, De Blasis E, De Blasis V, et al. Mirror therapy in complex regional pain syndrome type 1 of the upper limb in stroke patients. Neurorehabil Neural Repair 2009;23:792-799.

19. Hung GKN, Li CTL, Yiu AM, et al. Systematic review: effectiveness of mirror therapy for lower extremity post-stroke. Hong Kong J Occup Ther 2015;26:51-59.

20. Li Y, Wei Q, Gou W, et al. Effects of mirror therapy on walking ability, balance and lower limb motor recovery after stroke: a systematic review and meta-analysis of randomized controlled trials. Clin Rehabil 2018. https:// doi.org/10.1177/0269215518766642.

21. Broderick P, Horgan F, Blake C, et al. Mirror therapy for improving lower limb motor function and mobility after stroke: a systematic review and meta-analysis. Gait Posture 2018;63:208-220.

22. Higgins JPT, Green S. Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 [updated March 2011]. Cochrane Collab., 2011.

23. Jüni P, Witschi A, Bloch R, et al. The hazards of scoring the quality of clinical trials for meta-analysis. J Am Med Assoc 1999;282:1054-1060.

24. Armijo-Olivo S, Da Costa BR, Cummings GG, et al. PEDro or Cochrane to assess the quality of clinical trials? A meta-epidemiological study. PLoS One 2015;10: e0132634.

25. Arya KN, Pandian S, Kumar V. Effect of activity-based mirror therapy on lower limb motor-recovery and gait in stroke: a randomized controlled trial. Neuropsychol Rehabil 2017;0:1-18.

26. Ji SG, Cha HG, Kim MK, et al. The effect of mirror therapy integrating functional electrical stimulation on the gait of stroke patients. J Phys Ther Sci 2014;26:497-499.

27. Lee D, Lee G, Jeong J. Mirror therapy with neuromuscular electrical stimulation for improving motor function of stroke survivors: a pilot randomized clinical study. Technol Health Care 2016;24:503-511.

28. Salem HMA, Huang X. The effects of mirror therapy on clinical improvement in hemiplegic lower extremity rehabilitation in subjects with chronic stroke. Int J Med Health Biomed Bioeng Pharm Eng 2015;9:163-166.

29. Lee HJ, Kim YM, Lee DK. The effects of action observation training and mirror therapy on gait and balance in stroke patients. J Phys Ther Sci 2017;29:523-526.

30. Cha HG, Kim MK. Therapeutic efficacy of low frequency transcranial magnetic stimulation in conjunction with mirror therapy for sub-acute stroke patients. J Magn 2015;20:52-56.

31. In T, Lee K, Song C. Virtual reality reflection therapy improves balance and gait in patients with chronic stroke: Randomized controlled trials. Med Sci Monit 2016;22:4046-4053.

32. Xu Q, Guo F, Salem HMA, et al. Effects of mirror therapy combined with neuromuscular electrical stimulation on motor recovery of lower limbs and walking ability of patients with stroke: a randomized controlled study. Clin Rehabil 2017;31:1583-1591.

33. Ji SG, Kim MK. The effects of mirror therapy on the gait of subacute stroke patients: a randomized controlled trial. Clin Rehabil 2015;29:348-354.

34. Sütbeyaz S, Yavuzer G, Sezer N, et al. Mirror therapy enhances lower-extremity motor recovery and motor functioning after stroke: a randomized controlled trial. Arch Phys Med Rehabil 2007;88:555-559.

35. Cha HG, Kim MK. The effects of repetitive transcranial magnetic stimulation on the gait of acute stroke patients. J Magn 2015;20:129-132.

36. De S, Chopra C, Mehta DD, et al. Comparison between mirror therapy and mental imagery in improving ankle motor recovery in sub acute stroke patients. Indian J Physiother Occup Ther 2017;11:169-172.

37. Kawakami K, Miyasaka H, Nonoyama S, et al. Randomized controlled comparative study on effect of training to improve lower limb motor paralysis in convalescent patients with post-stroke hemiplegia. J Phys Ther Sci 2015;27:2947-2950.

38. Kim MK, Ji SG, Cha HG. The effect of mirror therapy on balance ability of subacute stroke patients. Hong Kong Physiother J 2016;34:27-32.

39. Kim MK, Choe YW, Shin YJ, et al. Effect of mirror use on lower extremity muscle strength of patients with chronic stroke. J Phys Ther Sci 2018;30:213-215.

40. Mohan U, Karthik babu S, Kumar KV, et al. Effectiveness of mirror therapy on lower extremity motor recovery, balance and mobility in patients with acute stroke: a randomized sham-controlled pilot trial. Ann Indian Acad Neurol 2013;16:634-639.

41. Wang H, Zhao Z, Jiang P, et al. Effect and mechanism of mirror therapy on rehabilitation of lower limb motor function in patients with stroke hemiplegia. Biomed Res 2017;28:10165-10170.

42. Hong Z, Sui M, Zhuang Z, et al. Effectiveness of neuromuscular electrical stimulation on lower limbs of patients with hemiplegia after chronic stroke: a systematic review. Arch Phys Med Rehabil 2018;99:1011-1022.

43. Middleton A, Braun CH, Lewek MD, et al. Balance impairment limits ability to increase walking speed in individuals with chronic stroke. Disabil Rehabil 2017;39:497-502.

44. Mahendran N, Kuys SS, Brauer SG. Recovery of ambulation activity across the first six months post-stroke. Gait Posture 2016;49:271-276.