Bilateral Arm Training

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Byl et al., 2013 PEDro: 5 Country: USA	15 patients with chronic stroke	Robotic virtual bilateral task specific repetitive training (TSRT) (n=5) vs. Robotic virtual unilateral TSRT (n=5) vs. TSRT with a physical therapist (n=5) <u>*Treatment details*</u>: 90-minutes/session, 2 times/week for 6 weeks. *Robotic virtual TSRT:* guided by the UL-EXO7 robotic orthosis to perform eight virtual task specific games that facilitated multi joint, mid-range motions at the shoulder, elbow and wrist but not the hand. For bilateral movement training, the intact limb assisted the paretic limb. *TSRT with a physical therapist:* training with a physical therapist using principles of neuroplasticity, learning-based, task-oriented, repetitive training. Tasks were mainly unilateral except when the less affected hand was needed to stabilize an object while the affected limb	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (-) Beck Depression Inventory (-) Saint Louis University Mental Status Examination (-) CAFÉ 40 + Stroke Impact Scale – Self-care domain combined score (-) Active range of motion – upper extremity (shoulder flexion/extension, adduction/abduction, internal/external rotation; elbow flexion/extension; wrist flexion/extension) (-) Manual Muscle Testing – total upper extremity (-) Motor Skill Performance Score (Box and Clock Test +Tapper Test combined) (-) Motor Proficiency Speed Score (Wolf-Motor Function Test + Digital Reaction Time Test combined) (-) Modified Ashworth Scale (-) Self-rated pain (0-10 ordinal scale) Note: Results reflect comparisons between bilateral robotic TSRT vs. unilateral robotic TSRT; bilateral robotic TSRT vs. PT-led TSRT; and unilateral robotic TSRT vs. PT-led TSRT.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		performed the task. Task practice involved reaching, grasping, object manipulation, and self-care activities; excluding the use of dynamic orthoses.	
Cauraugh & Kim, 2002 PEDro: 4 Country: USA	25 patients with chronic stroke and mild to moderate paresis	Bilateral arm training + EMG-triggered neuromuscular stimulation (n=10) vs. Unilateral arm training + EMG-triggered neuromuscular stimulation (n=10) vs. Unilateral active wrist/finger extension exercises (n=5) *Treatment details:* 90-minutes/session, 4 sessions over a 2-week period. *EMG-triggered neuromuscular stimulation:* 3 sets of 30 stimulation trials to the extensor carpi ulnaris and extensor communis digitorum muscles to facilitate wrist and finger extension. *Bilateral arm training:* wrist/finger extension exercises using both paretic and non-paretic hands.	**At 2 weeks (post-treatment):** (-) Box and Block Test* (-) Wrist strength* *Kinematics:* (-) Motor reaction time* * significant improvement from pre- to post-treatment by the bilateral arm training + EMG group. Between-group analysis were not clearly reported.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Unilateral arm training: unilateral active wrist/finger extension exercises using the paretic hand.	
Cauraugh, Kim & Duley, 2005 PEDro: 4 Country: USA	21 patients with chronic stroke	Bilateral arm training + active EMG-neuromuscular stimulation (n=11) vs. Unilateral active EMG-neuromuscular stimulation alone (n=10) *Treatment details:* 90-minutes/session, 4 sessions over a 2-week period. *Bilateral arm training:* movements in the less-affected wrist/fingers simultaneously with active stimulation of the paretic limb. *EMG-neuromuscular stimulation:* applied to the extensor communis digitorum and extensor carpi ulnaris muscles of the paretic limb.	**At 2 weeks (post-treatment):** *Kinematics:* (-) Median reaction time (-) Movement time* (-) Peak velocity* (bilateral movement) (-) Variability in peak velocity* (paretic arm only) (-) Percentage of total movement time in acceleration (-) Percentage of total movement time in deceleration phase* (bilateral movement) * significant improvement from pre- to post-treatment by the bilateral arm training + EMG group. Between-group analysis were not reported.
Cauraugh et al., 2010 PEDro: N/A (systematic review) Country: USA	N= 366 patients with stroke (16 comparison studies, 8 pre-post design studies)	Bilateral arm training vs.	**Results:** Large significant cumulative effect of bilateral arm training Significant effect of BATRAC

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Another upper limb intervention (unilateral training, neurodevelopmental therapy, functional movements, dose-matched therapeutic exercises, placebo electrical stimulation). Note: 4 types of bilateral arm training were identified: pure bilateral arm training, bilateral arm training with rhythmic auditory cueing, bilateral arm training coupled with EMG-triggered neuromuscular stimulation and active and/or passive movements, including robotics.	Significant effect of bilateral arm training combined with EMG-triggered neuromuscular stimulation Weak trend for active and/or passive movements Small non-significant effect size for pure bilateral therapy.
Chang et al., 2007 PEDro: N/A (non-randomized pre-post design study) Country: Taiwan	20 patients with chronic stroke	Robot-aided bilateral training and conventional rehabilitation *Treatment details:* 40-minutes/session, 24 sessions over 8 weeks *Robot-aided bilateral training:* bilateral force-induced isokinetic arm movement trainer (BFIAMT) was used in bilateral symmetric arm movement treatment mode to practice isokinetic push/pull movement at a constant velocity.	**At 8 weeks (post-treatment):** (+) Fugl-Meyer Assessment -Upper Extremity (FMA-UE) (-) Frenchay Arm Test (FAT) (-) Modified Ashworth Scale (MAS) (+) Isometric grip strength (+) Push strength (+) Pull strength *Reach kinematics:* (+) Movement time (+) Peak velocity (+) Percentage of time to peak velocity (+) Normalized jerk score **At 16 weeks (follow-up):** (+) FMA-UE (-) FAT (-) MAS

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(+) Isometric grip strength (+) Push strength (+) Pull strength *Reach kinematics:* (-) Movement time (-) Peak velocity (-) Percentage of time to peak velocity (-) Normalized jerk score Note: results indicate score change from baseline to post-treatment; and from baseline to follow-up.
Coupar et al., 2010 PEDro: N/A (systematic review) Country: United Kingdom	N=421 patients with acute to chronic stroke (14 RCTs)	Bilateral arm training vs. No treatment, usual care or placebo intervention (unilateral training or another upper limb intervention).	**Results:** (-) ADL (-) Extended ADL (-) Functional movement of the arm or hand (-) Upper limb motor impairment The systematic review concluded that there is insufficient evidence to make any recommendations regarding the relative effect of bilateral training compared to placebo, no intervention or usual care.
Desrosiers et al., 2005 PEDro: 6 Country: Canada	41 patients with subacute stroke	Bilateral arm training (n=20) vs.	**At 5 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (-) Grip strength (-) Box and Block Test

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Unilateral arm training (n=21) *Treatment details:* 45-minutes/session, 4 times/week for 5 weeks. *Bilateral arm training:* repeated practice of functional and bilateral tasks. *Unilateral arm training:* paretic arm training based on neurodevelopmental approach and was provided for the same frequency and duration. Both groups also received conventional rehabilitation.	(-) Purdue Pegboard Test (-) Finger-to-Nose Test (-) Upper Extremity Performance Test for the Elderly (TEMPA) – total TEMPA – Unilateral TEMPA – Bilateral (-) Functional Independence Measure (-) Assessment of Motor and Process Skills
Dispa et al., 2013 PEDro: 7 (cross-over design) Country: Belgium	10 patients with chronic stroke	Bilateral movement therapy with rhythmic auditory cueing (BATRAC) (n=5) vs. Unilateral movement therapy with Rhythmic Auditory Cueing (n=5) *Treatment details*: 1-hour/session, 3 times/week for 4 weeks.	**At 4 weeks (post-treatment):** (-) Purdue Pegboard Test (-) ABILHAND Questionnaire (-) SATIS-Stroke Questionnaire (-) Grip-lift parameters (preloading phase, loading phase, grip force maximal, hold ratio, cross-correlation coefficient, time shift) **At 8 weeks (follow-up):** (-) Purdue Pegboard Test (-) ABILHAND Questionnaire (-) SATIS-Stroke Questionnaire

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		BAT-RAC: 7 bilateral grip-lift, task-oriented exercises with auditory cueing performed in random order and included simultaneous bilateral tasks and alternated bilateral tasks focused on grip-lift movement. *Unilateral movement therapy with rhythmic auditory cueing*: grip-lift movements performed with the affected hand only; included auditory cueing.	(-) Grip-lift parameters (preloading phase, loading phase, grip force maximal, hold ratio, cross-correlation coefficient, time shift)
Hayner et al., 2010 PEDro: 5 Country: USA	12 patients with chronic stroke Patients were stratified according to degree of UE function ('less impaired' or 'more impaired')	Bilateral arm training (n=6) vs. Modified constraint induced movement therapy (mCIMT, n=6) *Treatment details:* 6 hours/day for 10 days *Bilateral training:* the use both arms during performance of functional tasks. *mCIMT:* wearing a mitt on unaffected UE for 6 hours/day OT and home practice.	**At 10 days (post-treatment) and at 6 months (follow-up):** (-) Wolf Motor Function Test
Hesse et al., 2005 PEDro: 7 Country: Germany	44 patients with subacute stroke and severe hemiparesis	Computerized bilateral arm training (n=22)	**At 6 weeks (post-treatment)** (+) Fugl-Meyer Assessment – Upper Extremity (FMA-UE)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		vs. Electromyography-initiated electrical stimulation of paretic wrist extensors (EMG ES, n=22) <u>*Treatment details:*</u> 20-minutes/session, 5 days/week for 6 weeks. *Computerized bilateral arm training:* a trainer that facilitated repetitive practice of passive and active bilateral forearm pronation/supination and wrist flexion/extension was used to facilitate passive/passive (mode 1), active/passive (mode 2) or active/active (mode 3) movement of the non-paretic/paretic limbs. *EMG ES:* 4-7-strains of monophasic exponential pulses (75 Hz; 0.5 ms; 0 to 80 mA) applied by 2 self-adhesive flexible electrodes (2.5×3 cm). The intensity was set to produce maximum wrist extension. Patients performed 60-80 wrist extensions per session, with an interstimulus interval between 8 and 15 s. If the patient could volitionally activate the wrist extensor muscle during the study, an EMG-initiated electrical stimulation was applied. A third flexible self-adhesive electrode, placed between the 2 stimulation electrodes, recorded the volitional muscular activity. The EMG activity level required to trigger the electrical stimulation was continuously adjusted near the	(+) Medical Research Council (MRC) – total score (wrist) (-) Modified Ashworth Scale (MAS) – total score **At 3 months (follow-up):** (+) FMA-UE (+) MRC – total score (-) MAS – total score

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		patients' highest level. Again, 60-80 wrist extensions were practiced per session. Both groups also received conventional rehabilitation.	
Hesse et al., 2003 PEDro: N/A (non-randomized pre-post study) Country: Germany	12 patients with chronic stroke	Bilateral arm training using a robotic arm trainer *Treatment details:* 15-minutes/session, 5 days/week for 3 weeks in addition to conventional rehabilitation. *Robotic arm trainer:* facilitated bilateral passive and active forearm pronation/supination and wrist dorsi/volarflexion in three modes: (1) passive mode with individually-adjusted speed and range of movement of both arms; (2) active mode whereby active movement of the less-affected arm facilitated mirror-like movement of the paretic arm; and (3) active mode whereby active movement of the paretic arm against resistance allows bilateral movement.	**At 3 weeks (post-treatment):** (-) Modified Ashworth Scale (MAS) – elbow (+) MAS – wrist (+) MAS – fingers (-) Rivermead Motor Assessment (RMA) **At 3 months (follow-up):** (-) MAS – elbow (-) MAS – wrist (-) MAS – fingers (-) RMA
Hijmans et al., 2011 PEDro: N/A (non-randomized study Country: The Netherlands	14 patients with chronic stroke	Bilateral computer training vs. Unilateral computer training *Treatment details*:	**At 7.5 weeks (post bilateral computer training):** (-) Fugl-Meyer Assessment – Upper Extremity* (-) Disabilities of Arm Shoulder and Hand (-) Wolf Motor Function Test

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		45-60 minutes/session, 8-10 sessions over 2.5 weeks/treatment. An interim washout period involved no intervention for 2-3 weeks. *Bilateral computer training:* the CyWee Z game controller was incorporated into a custom-made handlebar that participants held in a 'hands vertical' position (to facilitate radial/ulnar deviation with elbow and shoulder flexion/extension) or a 'hands horizontal' position (to facilitate wrist flexion/extension with elbow and shoulder flexion/extension). Games involved stationary or moving target hitting, sports games and puzzles, whereby bilateral movements were tracked and translated into mouse movements on the screen. *Unilateral computer training:* 4 simple mouse-based games (e.g. solitaire) on a PC computer using the unaffected arm.	* significant within-subject session effects. FMA scores were significantly higher following bilateral training compared to baseline, unilateral training (2.5 weeks) or post-washout time points.
Hsieh et al., 2017 PEDro: 6 Country: Taiwan	31 patients with subacute stroke	Robot-assisted bilateral arm training + task-oriented training (TOT) (n=16) vs. Time-matched TOT alone (n=15) *Treatment details*:	**At 4 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (-) Jamar Plus+ Digital Hand Dynamometer – grip strength (-) Box and Block Test (-) Modified Rankin Scale (-) Functional Independence Measure (-) Mini-Motionlogger Actigraph: wrist actigraphy (+) Stroke Impact Scale (SIS) – strength

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		2x 40-45 minutes/session, 2 sessions/day, 5 days/week for 4 weeks. *Robot-assisted bilateral arm training + TOT:* (1) Bi-Manu-Track robotic device was used for 40-45 minutes to provide bilateral repetitive and symmetric movements of forearms and wrists in passive and/or active modes; (2) TOT for 40-45 minutes that comprised 3 functional tasks (e.g. filling a bottle from a fountain; wipe the table; folding towels). *Time-matched TOT*: Comprised 2 phases of TOT, each of 40-45 minutes duration: (1) practicing specific and repetitive upper extremity tasks (e.g. reach to grasp, object manipulation, pinch and grip, sorting blocks/cards, pegs, stacking cones, flipping cards, stacking checkers); (2) performing 3 functional tasks that were more complicated, purposeful and multistep. Note: Consequently, the intervention group received 1 session of robot-assisted bilateral arm training + phase 2 of TOT; the control group received phases 1 + 2 of TOT.	(-) SIS – hand function (-) SIS – ADL/IADL (-) SIS – mobility (-) 11-point self-report fatigue scale Note: 3-month follow-up measurements were taken however follow-up data were not reported due to high attrition rate in the follow-up assessment.
Lee et al., 2017 PEDro: 7 Country: Republic of Korea	30 patients with chronic stroke	Bilateral upper extremity training (n=15) vs. Time-matched occupational therapy	**At 8 weeks (post-treatment):** (+) Fugl-Meyer Assessment – Upper Extremity (+) Box and Block Test (+) Barthel Index

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		(n=15) *Treatment details*: 30-minutes/session, 5 times/week for 8 weeks. Both groups received general occupational therapy for 30-minute sessions, 5 times/week for 8 weeks. Groups then received an additional session/day of bilateral training or conventional occupational therapy. *Bilateral upper extremity training:* 5 bilateral tasks were practiced - dishwashing, making coffee, typing, cutting fruit, and folding laundry. *Time-matched occupational therapy:* Bobath approach was used to facilitate typical postural reactions and to limit abnormal reflexive patterns; stretching exercises to enhance flexibility of the affected upper limb; resistance movements to improve muscle strength: and fine motor training to improve manipulation and dexterity.	Note: significant between-group differences reflect changes in scores from baseline to post-treatment.
Lin et al., 2009 PEDro: 7 Country: Taiwan	60 patients with chronic stroke	Bilateral arm training (BAT, n=20) vs. Modified constraint-induced movement therapy (mCIMT, n=20)	**At 3 weeks (post-treatment):** *BAT vs. CR:* (+) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) – overall score (+) FMA-UE – proximal score (+) FMA-UE – distal score

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		vs. Conventional rehabilitation (CR, n=20) <u>*Treatment details:*</u> 2 hour-sessions, 5 days/week for 3 weeks. *BAT:* simultaneous movements of both the affected and unaffected arms in functional tasks in symmetric or alternating patterns. These functional tasks also emphasized upper limb movements involved in daily activities, but focused on both limbs moving synchronously, such as lifting 2 cups, picking up 2 pegs, reaching forward or upward to move blocks, grasping and releasing 2 towels. *mCIMT:* intensive training of the affected upper limb in functional tasks for the same duration, with additional restraint of the less-affected hand for 6 hours/day. *CR:* time-matched upper limb training based on neurodevelopmental therapy and compensatory practice of functional tasks.	(-) Motor Activity Log – Amount of Use (MAL-AOU) (-) Motor Activity Log – Quality of Movement (MAL-QOM) (-) Functional Independence Measure (FIM) – total (-) FIM – self-care (-) FIM – sphincter control (-) FIM – transfers (-) FIM – locomotion (-) FIM – communication (-) FIM – social cognition (-) Stroke Impact Scape (SIS) – total score (-) SIS – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – ADL/IADL (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation *BAT vs. mCIMT:* (-) FMA-UE overall score (-) FMA-UE proximal score (-) FMA-UE distal score (-) MAL-AOU* (-) MAL-QOM* (-) FIM – total (-) FIM – self-care

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) FIM – sphincter control (-) FIM – transfers (-) FIM – locomotion* (-) FIM – communication (-) FIM – social cognition (-) SIS – total score* (-) SIS – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – ADL/IADL* (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation* *mCIMT vs. CR:* (+) FMA-UE – overall score (-) FMA-UE – proximal score (+) FMA-UE – distal score (+) MAL-AOU (+) MAL-QOM (-) FIM – total (-) FIM – self-care (-) FIM – sphincter control (-) FIM – transfers (+) FIM – locomotion (-) FIM – communication (-) FIM – social cognition (+) SIS – total score (-) SIS – strength

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) SIS – memory (-) SIS – emotion (-) SIS – communication (+) SIS – ADL/IADL (-) SIS – mobility (+) SIS – hand function (-) SIS – social participation * in favour of mCIMT vs. BAT
Lin et al., 2010 PEDro score: 6 Country: Taiwan	33 patients with chronic stroke	Bilateral arm training (n=16) vs. Occupational therapy with upper limb training (n=17) *Treatment details:* 2 hours/day, 5 days/week for 3 weeks *Bilateral arm training:* simultaneous upper limb movement with symmetric patterns during functional tasks (e.g. lifting, stacking, folding, turning objects). *OT upper limb training:* based on neurodevelopmental techniques.	**At 3 weeks (post-treatment):** (+) Fugl-Meyer Assessment – Upper Extremity (-) Functional Independence Measure (-) Motor Activity Log – Amount of Use (-) Motor Activity Log – Quality of Movement *Kinematic variables:* (+) Unilateral normalized movement time (NMT) (+) Unilateral normalized total distance (NTD) (-) Unilateral percentage of peak velocity (PPV) (+) Bilateral NMT (+) Bilateral NTD (+) Bilateral PPV

Bilateral Arm Training

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Luft et al., 2004 PEDro: 6 Country: USA	21 patients with chronic stroke	Bilateral arm training with rhythmic auditory cueing (BATRAC, n=9) vs. Upper limb exercises (n=12) *Treatment details:* 1 hour/session, 3 days/week for 6 weeks. *BATRAC:* auditory cues at individually determined rates of 0.67 to 0.97 Hz, where participants pushed and pulled bilaterally, in synchrony or alternation, 2 T-bar handles sliding in the transverse plane. *Upper-limb exercises:* standardized, dose-matched exercises based on neurodevelopmental principles that included thoracic spine mobilization, scapular mobilization, weight bearing with the paretic arm, and opening a closed fist.	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (-) Wolf Motor Function Test (WMFT) – strength (-) WMFT – time (-) University of Maryland Arm Questionnaire for Stroke (-) Elbow strength (-) Shoulder strength
Lum et al., 2002 PEDro: 6 Country: USA	30 patients with chronic stroke	Bimanual robot-assisted movement training (n=15) vs. Conventional upper limb rehabilitation (n=15)	**At 1 month (mid-treatment):** (+) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) – proximal score (-) FMA-UE – distal score (-) Functional Independence Measure (FIM) (-) Barthel Index (BI)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Treatment details: 1 hour/session, 24 sessions over 2 months. *Bimanual robot-assisted movement training:* goal-directed shoulder and elbow movements using the MIT-MANUS robot manipulator in passive, bimanual, active-assisted and active-constrained modes. *Conventional upper limb rehabilitation:* based on neurodevelopmental principles; participants were exposed to the MIT-MANUS robot for 5 minutes/session.	**At 2 months (post-treatment):** (+) FMA-UE – proximal score (-) FMA-UE – distal score (-) FIM (-) BI (+) Shoulder strength – flexion (-) Shoulder strength – extension (+) Shoulder strength – abduction (+) Shoulder strength – adduction (-) Shoulder strength – internal rotation (-) Shoulder strength – external rotation (+) Elbow strength – flexion (-) Elbow strength – extension (-) Reach (tabletop height) – forward (-) Reach (tabletop height) – forward medial (+) Reach (tabletop height) – forward lateral (+) Reach (tabletop height) – lateral (+) Reach (shoulder height) – forward (+) Reach (shoulder height) – forward medial (+) Reach (shoulder height) – lateral (+) Reach (shoulder height) – forward lateral **At 6 months (follow-up):** (-) FMA-UE – proximal score (-) FMA-UE – distal score (+) FIM (-) BI

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
McCombe Waller, Liu & Whitall, 2008 PEDro: 5 Country: USA	18 patients with chronic stroke (part of Whitall et al., 2000)	Bilateral arm training with rhythmic auditory cueing (BATRAC, n=9) vs. Dose-matched unilateral exercise (n=9) *Treatment details:* 1-hour/session, 3 sessions/week for 6 weeks. *BATRAC:* two 5-minute periods of bilateral inphase training (i.e. arms moving together) and two 5-minute periods of bilateral antiphase training (i.e. arms moving alternately), with 10-minute rest periods between each training period. *Dose-matched unilateral exercise:* based on neurodevelopmental principles.	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity* (-) modified Wolf Motor Function Test (mWMFT) – time* (-) mWMFT – weight* *Kinematic variables:* (-) Distance moved (-) Movement time (-) Peak acceleration (-) Peak velocity (+) Movement units (paretic hand, bilateral reach task) (+) Hand path accuracy (paretic and non-paretic hands, bilateral reach task) * Between-group differences not reported for these measures; significant within-group differences noted at post-treatment for BATRAC.
McCombe Waller & Whitall, 2004 PEDro: N/A (pre-post design study) Country: USA	10 patients with chronic stroke	Bilateral arm training with rhythmic auditory cueing (BATRAC) *Treatment details:* 1-hour/session, 3 sessions/week for 6 weeks. *BATRAC:* two 5-minute periods of bilateral inphase training (i.e. arms moving together) and two 5-minute	**At 6 weeks (post-treatment):** (+) Fugl-Meyer Assessment –Upper Extremity (+) Wolf Motor Function Test (+) University of Maryland Arm Questionnaire for Stroke (-) Paretic fine motor coordination (-) Non-paretic fine motor coordination* *significant improvement in consistency of non-paretic index finger tapping was reported.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		periods of bilateral antiphase training (i.e. arms moving alternately), with 10-minute rest periods between each training period.	
Morris et al., 2008 PEDro: 7 Country: United Kingdom	106 patients with acute stroke	Bilateral arm training (n=56) vs. Unilateral arm training (n=50) *Treatment details:* 20 minutes/session, 5 days/week for 6 weeks *Bilateral arm training:* standardized program whereby participants performed four complex multi-joint functional tasks using both arms simultaneously (move a doweling peg from tabletop to eye level; move a block from tabletop to shoulder height; take a glass to and from the mouth; and point to targets). *Unilateral arm training:* same program using the paretic arm only.	**At 6 weeks (post-treatment)** (-) Action Research Arm Test (ARAT) – total (-) ARAT – grasp (-) ARAT – grip (-) ARAT – pinch (-) ARAT – gross (-) Rivermead Motor Assessment (RMA) (-) Nine Hole Peg Test (9HPT) (-) modified Barthel Index (mBI) (-) Hospital Anxiety and Depression Scale (HADS) (-) Nottingham Health Profile (NHP) **At 18 weeks (follow-up):** (-) ARAT – total (-) ARAT – grasp (-) ARAT – grip (-) ARAT – gross (-) ARAT - pinch* (-) RMA (-) 9HPT* (-) mBI (-) HADS (-) NHP

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			* in favour of unilateral arm training vs. bilateral arm training
Morris & Van Wijck, 2012 PEDro: 8 Country: United Kingdom	102 patients with acute stroke	Bilateral arm training (n=56) vs. Unilateral arm training (n=50) *Treatment details:* 20 minutes/session, 5 days/week for 6 weeks *Bilateral arm training:* standardized progressive training program that involved simultaneous practice of bilateral upper limb tasks. *Unilateral arm training:* similar tasks to bilateral training using the hemiparetic arm only.	**At 6 weeks (post-treatment):** (-) Action Research Arm Test (ARAT) (+) Nine Hole Peg Test (9HPT) **At 18 weeks (follow-up):** (-) ARAT (-) 9HPT
Platz et al., 2001 PEDro: 3 Country: Germany	14 patients with subacute stroke	Bilateral arm training (n=7) vs. Unilateral arm training (n=7)	**At 1 week (post-treatment):** *Kinematic variables:* (-) Movement time (-) Variation of movement (-) Spatial accuracy

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Treatment details: 30 minutes/session, 5 days/week for 1 week. Intervention consisted of practicing three tasks (aiming movements, fast tapping, picking up and stacking small wooden sticks) using the affected arm only (*unilateral arm training*) or bilateral symmetrical movements (*bilateral arm training*).	
Rosa et al., 2010 PEDro: 1 Country: Portugal	8 patients with chronic stroke	Bilateral Arm Training with Rhythmic Auditory Cueing (BATRAC, n=4) vs. Unilateral arm training (n=4) *Treatment details:* 20 minutes of active training within a 60-minute session, 3 times/week for 6 weeks. *BATRAC:* BATRAC platform was used to perform movements with the platform bars (to bring up and push the two bars) using the noise of a stop watch to time training. This movement required shoulder abduction and elbow flexion/extension. The comfortable rhythm for each patient to perform the tasks was chosen in the first session, and remained constant throughout the study.	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity* (-) Purdue Pegboard Test** Note: between-group differences were not reported. *improvements in 1/4 BATRAC participants vs. 3/4 unilateral training group participants; 2/4 BATRAC participants demonstrated poorer scores. ** improvements in 2/3 BATRAC participants.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Unilateral arm training: BATRAC platform was used, following the same procedures as the bilateral group, except that only the hemiparetic upper-limb was used to move the bars. Also, the Manual Dexterity Test of Minnesota was used by this group to match active time participation with the intervention group.	
Sampson et al., 2012 PEDro: N/A (case series design) Country: New Zealand	5 patients with subacute (n=1)/chronic (n=4) stroke	Bilateral Upper Limb Trainer (BUiLT) *Treatment details:* 45 minutes/session, 4 sessions/week for 6 weeks. *BUiLT:* symmetrical, bilateral arm exercises in a forced and self-assisted manner using virtual reality. Arm movements include shoulder and elbow flexion/extension, shoulder abduction/adduction, external/internal rotation and combined movement patterns. Participants also received conventional rehabilitation.	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (-) Shoulder isometric strength: flexion, extension, abduction, external/internal rotation (-) Elbow isometric strength: flexion, extension Note: results indicate positive trends towards improvement; statistical data was not reported.
Shahine & Shafshak, 2014 PEDro: 7 Country: Egypt	76 patients with chronic stroke	Bilateral arm training with rhythmic auditory cueing (BATRAC, n=40) vs. Unilateral upper extremity rehabilitation program (n=39)	**At 8 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (+) Motor evoked potential (MEP) of the paretic abductor pollicis brevis (PAPB): transcranial magnetic stimulation threshold (%) (+) MEP of the PAPB: central motor conduction time (ms)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Treatment details: 1-hour/session, 3 times/week for 8 weeks. *BATRAC:* bilateral upper extremity exercises performed using a pushing/pulling T-bar handle apparatus in time to an auditory stimulus. *Unilateral exercises:* based on neurodevelopmental principles and included range of motion, strength and fine motor task exercises.	(+) MEP of the PAPB: amplitude ratio
Shim & Jung, 2015 PEDro: 4 Country: Republic of Korea	20 patients with chronic stroke	Bilateral arm training (n=10) vs. Unilateral arm training (n=10) *Treatment details*: 30-minutes/session, 5 times/week for 6 weeks. Training consisted of performing functional tasks with both (BAT) or only the affected (UAT) upper extremity.	**At 6 weeks (post-treatment):** (+) Functional Independence Measure (FIM) – motor score (-) FIM – cognitive score (+) FIM – total score (+) Manual Function Test – affected side (+) Actisleep accelerometry affected arm: amount of activity – axis x, y*, z, total* (+) Actisleep acceletometry affected arm: intensity of activity – sedentary*, light, lifestyle, moderate* (-) Actisleep accelerometry unaffected arm: amount of activity – axis x, y, z, total (-) Actisleep acceletometry unaffected arm: intensity of activity – sedentary, light, lifestyle, moderate

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			* significant between-group differences, favoring BAT vs. UAT.
Singer et al., 2013 PEDro: 5 Country: Australia	24 patients with chronic stroke	Bilateral task specific arm training (n=12) vs. Unilateral task specific arm training (n=12) <u>*Treatment details*</u>: 30-minute/day (average), 6-7 days/week for 6 weeks. *Bilateral or unilateral task specific arm training:* performed at home and consisted of functional tasks performed bilaterally or unilaterally (e.g. grasp/release a cup, pour water into a cup, sort cards, open an envelope, unscrew a jar/bottle lid). Both groups received concurrent home-based *electromyographically triggered electrical muscle stimulation (EMG-ES)* using a NeuroTrac™ ETS device to stimulate wrist and finger extensors of the affected arm via surface electrodes over the extensor muscle with threshold set at 40% f maximal contraction of the wrist/finger extensors for each individual. The duration of each session was customized to the individual according	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) Arm Motor Ability Test (AMAT) (-) Transcranial magnetic stimulation: inter-hemispheric inhibition **At 1 month (follow-up):** (-) FMA-UE (-) AMAT (-) Transcranial magnetic stimulation: inter-hemispheric inhibition **At 3 months (follow-up):** (-) FMA-UE (-) AMAT (-) Transcranial magnetic stimulation: inter-hemispheric inhibition

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		to the quality of the practice and their ability to cotinine to trigger the device effectively.	
Sethy et al., 2016 PEDro: 4 Country: India	41 patients with chronic stroke	Bilateral arm training (BAT; n=14) or Modified constraint induced movement therapy (mCIMT; n=13) or Conventional occupational therapy (OT; n=14) *Treatment details*: 60-minutes/session, 5 days/week for 8 weeks. *BAT:* repetitive practice of bilateral tasks including block placement, peg targeting, peg inversion, object transferring. *mCIMT:* 1 hr OT where activities of daily life were practiced using facilitating neurodevelopmental techniques "shaping", followed by wearing a cotton glove on the unaffected hand for 5 hours while performing daily live activities.	**At 8 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE): proximal arm score (-) FMA – UE: distal arm score (-) Action Research Arm Test (-) Motor Activity Log (MAL) – Amount of Use (-) MAL – Quality of Use Note: no between-group analyses are performed nor reported on in this study.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		OT: based on Bobath Neurodevelopmental Therapy including weight bearing, reflect inhibiting activities, trunk rotation and scapular protraction to reduce spasticity.	
Stinear et al., 2008 PEDro: 5 Country: New Zealand	32 patients with chronic stroke	Active-passive bilateral therapy (APBT) and motor practice (n=16) vs. Motor practice alone (n=16) *Treatment details:* *APBT*: 10-15 minutes prior to every motor practice session *Motor practice*: 3x10-minute sessions/day for 4 weeks. *APBT:* active rhythmic flexion and extension of the non-paretic wrist to generate mirror-symmetric movements in the paretic limb, using a mechanical device. *Motor practice:* transporting or manipulating blocks using the paretic upper limb.	**At 4 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) National Institutes of Health Stroke Scale (NIHSS) (-) Grip strength **At 8 weeks (follow-up):** (+) FMA-UE (-) NIHSS (-) Grip strength
Stinear & Byblow, 2004 PEDro: N/A (non-randomized study) Country: New Zealand	9 patients with subacute (n=3)/chronic (n=6) stroke	Active-passive bimanual movement therapy *Treatment details:* 6 x 10-minute sessions/day for 4 weeks	**At 4 weeks (post-treatment):** (+) Fugl-Meyer Assessment – Upper Extremity (-) Grip strength (-) Wrist strength: flexion (-) Wrist strength: extension

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Active-passive bimanual movement therapy: performed using the purpose-built Manipulanda machine. Passive rhythmical flexion and extension of the paretic wrist was facilitated by active flexion and extension of the less-affected wrist at a self-paced movement rate. Synchronous (i.e. both hands reached peak flexion/extension simultaneously) or asynchronous (i.e. peak flexion of the less-affected hand lagged peak flexion of the paretic hand) patterns were used.	Note: (+) indicates significant improvements from baseline to post-treatment.
Stoykov et al., 2009 PEDro: 5 Country: USA	24 patients with chronic stroke and moderate upper limb impairment	Bilateral arm training (n=12) vs. Unilateral arm training (n=12) *Treatment details:* 1-hour/session, 3 times/week for 8 weeks. Interventions consisted of 6 training tasks that incorporated (a) discrete movements (wiping a table; reaching and placing objects), and (b) rhythmic movements paced by a metronome (pushing/pulling movement; cycling, shoulder and elbow coupling, elbow extension during horizontal reach).	**At 8 weeks (post-treatment):** (+) Motor Assessment Scale (MAS) – upper arm function (-) MAS – hand movements (-) MAS – advanced hand activities (-) MAS – total (-) Motor Status Scale (MSS) – shoulder/elbow (-) MSS – wrist/hand (-) Shoulder strength: flexion/extension, external/internal rotation (-) Elbow strength: flexion/extension (-) Wrist strength: flexion/extension (-) Grip strength

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Bilateral arm training group performed tasks simultaneously with both hands whereas the *unilateral arm training* group performed the activities with the affected arm only.	
Summers et al., 2007 PEDro: 6 Country: Australia	12 patients with chronic stroke	Bilateral arm training (n=6) vs. Unilateral arm training (n=6) *Treatment details:* 1 session/day (duration not specified), for 6 days. *Bilateral arm training:* 50 trials of a dowel placement task moving both arms synchronously. *Unilateral arm training:* performed the same task using the impaired arm only.	**At 6 days (post-treatment):** (+) Modified Motor Assessment Scale (mMAS) – upper arm function (+) mMAS – hand movements (+) mMAS – advanced hand activities **Following each training session:** *Upper extremity kinematics:* (-) Movement time (-) Velocity (-) Curvature of arm trajectories and elbow angle
Suputtitada et al., 2004 PEDro: 6 Country: Thailand	69 patients with chronic stroke	Bilateral arm training (BAT, n=36) vs. Constraint induced movement therapy (CIMT, n=33)	**At 2 weeks (post-treatment):** (-) Action Research Arm Test (ARAT) – total* (-) ARAT – grasp* (-) ARAT – grip* (-) ARAT – pinch* (-) ARAT – gross* (-) Hand grip strength

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Treatment details: 6 hours/day, 5 days/week for 2 weeks. *BAT:* bimanual exercises based on neurodevelopmental techniques. *CIMT:* participants wore a restraint on the less-affected hand at home.	(-) Pinch strength* * Between-group differences were seen in favour of CIMT vs. BAT.
van Delden et al., 2012 PEDro: N/A (systematic review) Country: The Netherlands	N = 452 patients with acute or chronic stroke and mild, moderate or severe upper limb (UL) paresis (9 RCTs)	Bilateral arm training vs. Unilateral arm training *Treatment details:* Range: 20 minutes - 6 hours/day, 3 - 6 days/week for 1 - 8 weeks *Bilateral arm training:* functional bilateral training, NDT-based bilateral arm training, bilateral arm training with rhythmic auditory cueing. *Unilateral arm training:* functional unilateral training, NDT-based unilateral arm training, CIMT, mCIMT, Forced Use Therapy.	**At post-treatment:** (-) Fugl-Meyer Assessment – Upper Extremity (-) Action Research Arm Test (-) Wolf Motor Function Test* (-) Motor Assessment Scale (-) Motor Activity Log (MAL) – Amount of Use** (-) MAL – Quality of Movement** * Marginally significant standardized mean difference (SMD) among patients with acute or chronic stroke and mild UL paresis, in favour of unilateral arm training vs. bilateral arm training ** Marginally significant mean difference (MD) among patients with chronic stroke and mild UL paresis, in favour of unilateral arm training vs. bilateral arm training.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
van Delden et al., 2013 PEDro: 6 Country: The Netherlands	60 patients with acute/subacute stroke	Modified bilateral arm training with rhythmic auditory cueing (mBATRAC, n = 19) vs. Modified constraint induced movement therapy (mCIMT, n=22) vs. Conventional rehabilitation (CR, n=19) <u>*Treatment details*</u>: 60-minutes/session, 3 sessions/week for 6 weeks. *mBATRAC:* modification of the original BATRAC protocol, targeting rhythmic flexion and extension movements of the wrist rather than movements of proximal parts of the upper limb. The apparatus used was mounted on a chair with arm rests and rhythmic wrists rotations in the horizontal plane were paced by an auditory metronome at an individually selected tempo between 0.8 and 1.8 Hz. *mCIMT:* unilateral repetitive task practices and shaping of the desired movements following bottom-up approach (from simple gross-motor functions of the arm to more	**At 6 weeks (post-treatment):** (-) Action Research Arm Test (ARAT) – grasp (-) ARAT – grip (-) ARAT – pinch (-) ARAT – gross movement (-) Motricity Index (MI) – upper extremity (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) Nine Hole Peg Test (9HPT) (-) Erasmus modification of the Nottingham Sensory Assessment (EmNSA) (-) Motor Activity Log – Amount of Use (MAL-AOU) (-) Motor Activity Log – Quality of Movement (MAL-QOM) (-) Stroke Impact Scale (SIS) – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – activities of daily living (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation **At 12 weeks (follow-up):** (-) ARAT – grasp (-) ARAT – grip (-) ARAT – pinch (-) ARAT – gross movement (-) MI – upper extremity

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		complex in-hand manipulations and combinations of movements in activities of daily life). *CR:* exercise therapy on the basis of existing guidelines for upper limb rehabilitation after stroke.	(-) FMA-UE (-) 9HPT (-) EmNSA (-) MAL-AOU (-) MAL-QOM (+) SIS – strength* (-) SIS – memory (+) SIS – emotion* (-) SIS – communication (-) SIS – activities of daily living (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation Note: results reflect comparisons between mBATRAC vs. mCIMT; mBATRAC vs. CR; mCIMT vs. CR. * significant between-group differences, favoring CR vs. mBATRAC.
van der Lee et al., 1999 PEDro: 7 Country: The Netherlands	66 patients with chronic stroke	Bimanual upper extremity training (n=33) vs. Forced use therapy of the affected upper limb (n=33) *Treatment details:*	**At 3 weeks (post-treatment):** (-) Action Research Arm Test (ARAT)* (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) Motor Activity Log – Amount of Use (MAL-AOU)* (-) MAL - Quality of Movement (MAL-QOM) (-) MAL - Problems

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		6 hours/day, 5 days/week for 2 weeks. *Bimanual upper extremity training:* based on neurodevelopmental techniques. All activities were performed bimanually and, if necessary, the affected arm was supported with the unaffected hand. Symmetry of posture and inhibition of inappropriate "synergistic" movements were emphasized. *Force use therapy of the affected upper limb:* intensive training of the affected arm; participants were encouraged to wear a splint for activities at home.	(-) Rehabilitation Activities Profile (RAP) – personal care (-) RAP – occupation **At 6 weeks, 6 months, and 12 months (follow-up):** (-) ARAT* (-) FMA-UE (-) MAL-AOU (-) MAL-QOM (-) MAL-Problems (-) RAP – personal care (-) RAP – occupation *Note: while intention-to-treat indicated no significant differences, on-treatment analysis revealed significant between-group differences in favour of forced-use therapy vs. bilateral arm training.
Waller et al., 2014 PEDro: 7 Country: USA	30 patients with chronic stroke	Bilateral proximal arm training + unilateral task-oriented training (n=15) vs. Unilateral task-oriented training (n=15) *Treatment details*:	**At 6 weeks (post-phase 1 of treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) Modified Wolf Motor Function Test (mWMFT) (-) Box and Block Test (BBT) (-) University of Maryland Arm Questionnaire for Stroke (UMAQS) (-) Modified Ashworth Scale (MAS)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Phase 1 (bilateral proximal arm training OR unilateral task-oriented training): 60-minutes/session, 3 sessions/week for 6 weeks; Phase 2 (unilateral task-oriented training): 60-minutes/session, 3 sessions/week for 6 weeks. *Bilateral proximal arm training:* performed using the BATRAC Tailwind device. *Unilateral task-oriented training:* performed using a protocol of motor retraining with the Saeboflex device and included functional and repetitive tasks of reaching, grasping and hand/arm orientation.	**At 12 weeks (post-phase 2 of treatment):** (-) FMA - UE (+) mWMFT (-) BBT (+) UMAQS (-) MAS **At 18 weeks (follow-up):** (-) FMA-UE (+) mWMFT (-) BBT (+) UMAQS (-) MAS Note: significant between-group differences refer to mean change of scored from baseline to 12 weeks (post-Phase 2 of treatment); and from baseline to 18 weeks (follow-up).
Whitall et al., 2000 PEDro: N/A (pre-post design study) Country: USA	14 patients with chronic stroke	Bilateral arm training with rhythmic auditory cueing (BATRAC) *Treatment details:* 1 hour/session, 3 sessions/week for 6 weeks. *BATRAC:* 4 x 5-minute cycles of active continuous training with arms moving in simultaneous or alternating push/pull movements in time with a metronome auditory	**At 6 weeks (post-treatment):** (+) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) – motor performance section (+) Wolf Motor Function Test (WMFT) – time (-) WMFT – strength (-) WMFT – function (+) University of Maryland Arm Questionnaire for Stroke (UMAQS) (-) Shoulder isometric strength – flexion (paretic) (-) Shoulder strength – extension (paretic)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		cueing, using a T-bar, interspersed by 10-minute rest periods.	(-) Shoulder strength – flexion (non-paretic) (-) Shoulder strength – extension (non-paretic) (-) Elbow isometric strength – flexion (paretic) (-) Elbow strength – extension (paretic) (-) Elbow strength – flexion (non-paretic) (-) Elbow strength – extension (non-paretic) (+) Wrist isometric strength – flexion (paretic) (-) Wrist strength – extension (paretic) (-) Wrist strength – flexion (non-paretic) (-) Wrist strength – extension (non-paretic) (-) Grip strength: BASELINE Hydraulic Hand Dynamometer (-) Shoulder active range of motion (aROM) – flexion (-) Shoulder passive range of motion (pROM) – flexion (+) Shoulder aROM – extension (-) Shoulder pROM – extension (-) Shoulder aROM – abduction (-) Shoulder pROM – abduction (-) Shoulder aROM – adduction (-) Shoulder pROM – adduction (-) Shoulder pROM – extension (-) Elbow aROM – flexion (-) Elbow pROM – flexion (-) Elbow aROM – extention (-) Elbow pROM – extension (+) Wrist aROM – flexion (+) Wrist pROM – flexion (-) Wrist aROM – extension

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Wrist pROM – extension (+) Thumb aROM – opposition (-) Thumb pROM - opposition **At 2 months (follow-up):** (+) FMA-UE motor performance score (+) WMFT – time (-) WMFT – strength (-) WMFT –function (+) UMAQS (-) Shoulder isometric strength – flexion (paretic) (-) Shoulder strength – extension (paretic) (-) Shoulder strength – flexion (non-paretic) (-) Shoulder strength – extension (non-paretic) (-) Elbow isometric strength – flexion (paretic) (-) Elbow strength – extension (paretic) (+) Elbow strength – flexion (non-paretic) (-) Elbow strength – extension (non-paretic) (-) Wrist isometric strength – flexion (paretic) (-) Wrist strength – extension (paretic) (-) Wrist strength – flexion (non-paretic) (+) Wrist strength – extension (non-paretic) (-) Grip strength: BASELINE Hydraulic Hand Dynamometer (-) Shoulder aROM – flexion (-) Shoulder pROM – flexion (-) Shoulder aROM – extension (-) Shoulder pROM – extension (-) Shoulder aROM – abduction

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Shoulder pROM – abduction (-) Shoulder aROM – adduction (-) Shoulder pROM – adduction (-) Shoulder pROM – extension (-) Elbow aROM – flexion (-) Elbow pROM – flexion (-) Elbow aROM – extention (-) Elbow pROM – extension (-) Wrist aROM – flexion (+) Wrist pROM – flexion (-) Wrist aROM – extension (-) Wrist pROM – extension (+) Thumb aROM – opposition (-) Thumb pROM - opposition Note: + indicates improvement from baseline scores.
Whitall et al., 2011 PEDro: 6 Country: USA	111 patients with chronic stroke	Bilateral arm training and rhythmic auditory cueing (BATRAC, n=55) vs. Dose-matched unilateral therapeutic exercises (n=56) *Treatment details:* 1 hour/session, 3 sessions/week for 6 weeks.	**At 6 weeks (post-treatment):** (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) (-) Wolf Motor Function Test (WMFT) – time (-) WMFT – strength (-) WMFT – function (-) Stroke Impact Scale (SIS) – total (-) SIS – emotion (-) SIS – hand function (-) SIS – strength

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		BATRAC: 4 x 5-minute cycles of active continuous training with arms moving in simultaneous or alternating push/pull movements in time with a metronome auditory cueing, using a T-bar, interspersed by 10-minute rest periods. *Dose matched unilateral therapeutic exercises:* customized set of 4 exercises based on neurodevelopmental principles including (i) thoracic spine mobilization with weight shifting, (ii) scapular mobilization, (iii) weight bearing with the paretic arm (elbow fixed), and (iv) opening the hand with finger extension; participants were encouraged to actively move during handling and used handling techniques that facilitate "normal" positions of body and limbs.	(-) Shoulder isometric strength – flexion (paretic) (-) Shoulder strength – extension (paretic) (-) Shoulder strength – flexion (non-paretic) (-) Shoulder strength – extension (non-paretic) (*) Elbow isokinetic strength – flexion (paretic) (-) Elbow strength – extension (paretic) (+) Elbow strength – flexion (non-paretic) (-) Elbow strength – extension (non-paretic (-) Wrist isometric strength – flexion (paretic) (+) Wrist strength – extension (paretic)* (+) Wrist strength – flexion (non-paretic) (-) Wrist strength – extension (non-paretic) **At 4 months (follow-up):** (-) FMA-UE (-) WMFT – time (-) WMFT – strength (-) WMFT – function (+) SIS – total (-) SIS – emotion (-) SIS – hand (-) SIS – strength (-) Shoulder isometric strength – flexion (paretic) (-) Shoulder strength – extension (paretic) (-) Shoulder strength – flexion (non-paretic) (-) Shoulder strength – extension (non-paretic) (-) Elbow isokinetic strength – flexion (paretic) (-) Elbow strength – extension (paretic)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(+) Elbow strength – flexion (non-paretic) (-) Elbow strength – extension (non-paretic (-) Wrist isometric strength – flexion (paretic) (+) Wrist strength – extension (paretic)* (+) Wrist strength – flexion (non-paretic) (-) Wrist strength – extension (non-paretic) * Note: between-group differences in paretic wrist extension strength, favoring control therapy vs. BATRAC.
Wu et al., 2010 PEDro: 2 Country: Taiwan	23 patients with chronic stroke	Bilateral arm training (BAT, n=11) vs. Modified Constraint Induced Movement Therapy (mCIMT, n=12) *Treatment details:* 2 hours/session, 5 sessions/week for 3 weeks. *BAT:* symmetric or alternating movements of both upper limbs during performance of functional tasks. *mCIMT:* restrictive mitt worn on the unaffected hand for 6 hours/day to train the affected limb during performance of functional tasks; and intensive training of the affected upper limb.	**At 3 weeks (post-treatment):** (-) Action Research Arm Test (-) Fugl-Meyer Assessment – Upper Extremity (-) Motor Activity Log (MAL) – Amount of Use (-) MAL – Quality of Movement Note: between-group differences were not reported. Most participants demonstrated improved scores on all measures at post-treatment.

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Wu et al., 2011 PEDro: 6 Country: Taiwan	66 patients with chronic stroke	Bilateral Arm Training (BAT, n=22) vs. Modified Constraint Induced Movement Therapy (mCIMT, n=22) vs. Conventional rehabilitation (n=22) *Treatment details:* All groups received occupational therapy 2 hours/day, 5 days/week for 3 weeks. *BAT:* bilateral movement in symmetric or alternating patterns while performing functional tasks; *mCIMT:* restrictive mitt worn on the unaffected hand for 6 hours/day to train the affected limb during performance of functional tasks; and intensive training of the affected upper limb. *Conventional rehabilitation:* neurodevelopmental therapy and compensatory practice of functional tasks using unaffected and/or both arms.	**At 3 weeks (post-treatment):** *BAT vs. mCIMT:* (-) Wolf Motor Function Test (WMFT) – time (-) WMFT – functional ability (-) WMFT – strength (-) Motor Activity Log – amount of use (MAL-AOU)* (-) Motor Activity Log – quality of movement (MAL-QOM)* *Kinematic variables:* (-) Unilateral normalized movement time (NMT) (+) Unilateral normalized movement unit (NMU)* (-) Unilateral peak velocity (PV) (-) Unilateral percentage of movement time when peak velocity occurred (PPV) (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral PV (-) Bilateral PPV * in favour of mCIMT vs. BAT *BAT vs. CR:* (-) WMFT – time (-) WMFT – functional ability (-) WMFT – strength (-) MAL-AOU (-) MAL-QOM

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			Kinematic variables: (-) Unilateral NMT (+) Unilateral NMU (+) Unilateral PV (-) Unilateral PPV (-) Bilateral NMT (+) Bilateral NMU (+) Bilateral PV (-) Bilateral PPV *mCIMT vs. CR:* (+) WMFT – time (+) WMFT – functional ability (-) WMFT – strength (+) MAL-AOU (+) MAL-QOM *Kinematic variables:* (-) Unilateral NMT (+) Unilateral NMU (-) Unilateral PV (-) Unilateral PPV (-) Bilateral NMT (+) Bilateral NMU (-) Bilateral PV (-) Bilateral PPV

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
Wu et al., 2012. PEDro: 7 Country: Taiwan	42 patients with chronic stroke	Therapist-based bilateral arm training (TBAT, n=14) vs. Robot-assisted bilateral arm training (RBAT, n=14) vs. Conventional rehabilitation (n=14) *Treatment details:* 90-105-minutes/session, 5 sessions/week for 4 weeks. *TBAT:* therapist-supervised bilateral multijoint functional tasks. *RBAT:* passive/active single-joint (forearm pronation/supination, wrist flexion/extension) movements using the Bi-Manu-Track arm trainer. Both TBAT and RBAT groups ended sessions with 15-20 minutes of unilateral and bilateral functional training and 5 minutes of tone-normalization if necessary. Conventional rehabilitation: weight-bearing, stretching and strengthening of the paretic arm, unilateral and bilateral fine motor tasks, balance and compensatory practice of functional tasks.	**At 4 weeks (post-treatment):** *TBAT vs. CR:* (-) Fugl-Meyer Assessment – Upper Extremity (FMA-UE) – total score (-) FMA-UE – proximal score (+) FMA-UE – distal (-) Motor Activity Log – Amount of Use (MAL-AOU) (-) Motor Activity Log - Quality of Movement (MAL-QOM) (-) Stroke Impact Scale (SIS) – total (-) SIS – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – ADL/IADL (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation (-) SIS – physical function domain *Kinematic variables:* (+) Unilateral normalized movement time (NMT) (+) Unilateral normalized movement unit (NMU) (+) Unilateral normalized trunk displacement (NTrD) (-) Unilateral trunk contribution slope for the middle part

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Unilateral angular changes of shoulder flexion (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral NTrD (+) Bilateral trunk contribution slope for the middle part (-) Bilateral angular changes of shoulder flexion *RBAT vs. CR:* (-) FMA-UE – total score (-) FMA-UE – proximal score (-) FMA-UE – distal score (-) MAL-AOU (-) MAL-QOM (+) SIS – total (+) SIS – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – ADL/IADL (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation (+) SIS – physical function domain *Kinematic variables:* (-) Unilateral NMT (-) Unilateral NMU (-) Unilateral NTrD

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Unilateral trunk contribution slope for the middle part (+) Unilateral angular changes of shoulder flexion (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral NTrD (-) Bilateral trunk contribution slope for the middle part (+) Bilateral angular changes of shoulder flexion *TBAT vs. RBAT:* (-) FMA-UE – total score (-) FMA-UE – proximal score (-) FMA-UE – distal score (-) MAL-AOU (-) MAL-QOM (-) SIS – total (-) SIS – strength (-) SIS – memory (-) SIS – emotion (-) SIS – communication (-) SIS – ADL/IADL (-) SIS – mobility (-) SIS – hand function (-) SIS – social participation (-) SIS – physical function domain *Kinematic variables:* (-) Unilateral NMT

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Unilateral NMU (-) Unilateral NTrD (+) Unilateral trunk contribution slope for the middle part* (+) Unilateral angular changes of shoulder flexion** (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral NTrD (-) Bilateral trunk contribution slope for the middle part (-) Bilateral angular changes of shoulder flexion * in favour of TBAT vs. RBAT ** in favour of RBAT vs. TBAT
Wu et al., 2013 PEDro: 7 Country: Taiwan	53 patients with chronic stroke	Bilateral robot-assisted arm training (n=18) vs. Unilateral robot-assisted arm training (n=18) vs. Conventional rehabilitation (n=17)	**At 4 weeks (post-treatment):** *Bilateral vs. unilateral robot-assisted arm training:* (+) Wolf-Motor Function Test (WMFT) – time* (-) WMFT – functional ability (-) Motor Activity Log – Amount of Use (MAL-AOU) (-) Motor Activity Log – Quality of Movement (MAL-QOM) (-) ABILHAND Questionnaire *Kinematic variables:* (-) Unilateral normalized movement time (NMT)

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
		Treatment details: 90-105-minutes/session, 5 sessions/week for 4 weeks. *Bilateral and unilateral robot assisted arm training:* performed using the Bi-Manu-Track robotic arm trainer to facilitate bilateral or unilateral (paretic) forearm pronation/supination and wrist flexion/extension in 3 modes: passive-passive; active-passive; and active/active. *Conventional rehabilitation:* weight bearing, stretching, and strengthening of the paretic arm, coordination tasks, unilateral and bilateral fine motor tasks, and balance activities.	(-) Unilateral normalized movement units (NMU) (-) Unilateral trunk contribution (-) Unilateral slope start (-) Unilateral slope mid (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral trunk contribution (+) Bilateral slope start (-) Bilateral slope mid * favoring unilateral vs. bilateral robot-assisted arm training *Bilateral robot-assisted arm training vs. conventional rehabilitation* (-) WMFT – time (-) WMFT – functional ability (-) MAL-AOU (-) MAL-QOM (-) ABILHAND Questionnaire *Kinematic variables:* (-) Unilateral NMT (-) Unilateral NMU (-) Unilateral trunk contribution (-) Unilateral slope start (-) Unilateral slope mid (-) Bilateral NMT (-) Bilateral NMU

Author, Year PEDro Score, Country	Sample size	Intervention	Outcome and significance: (+) significant (-) not significant
			(-) Bilateral trunk contribution (-) Bilateral slope start (-) Bilateral slope mid *Unilateral robot-assisted arm training vs. conventional rehabilitation:* (-) WMFT – time (-) WMFT – functional ability (-) MAL-AOU (-) MAL-QOM (-) ABILHAND Questionnaire *Kinematic variables:* (-) Unilateral NMT (-) Unilateral NMU (-) Unilateral trunk contribution (-) Unilateral slope start (-) Unilateral slope mid (-) Bilateral NMT (-) Bilateral NMU (-) Bilateral trunk contribution (-) Bilateral slope start (+) Bilateral slope mid** ** favoring conventional rehabilitation vs. unilateral robot-assisted arm training.