National Institute for Health and Care Excellence

Draft for consultation

Stroke rehabilitation in adults (update)

[M] Evidence reviews for robot-assisted arm training

NICE guideline GID-NG10175

Evidence reviews underpinning recommendation 1.13.18 in the NICE guideline

April 2023

Draft for Consultation

These evidence reviews were developed by the Guideline Development Team at NICE

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1.1 Review question

In people after stroke, what is the clinical and cost effectiveness of robot-assisted arm training in improving function and reducing disability?

1.1.1 Introduction

Robot assisted arm training is an intervention which allows people with arm weakness following stroke to perform repetitive functional tasks with the aim of improving strength and function. Repetitive functional task practice is known to help recovery following stroke and robot assisted arm training is a potential mechanism to increase the intensity and frequency of rehabilitation. In previous guidance, robot assisted arm training could only be recommended in the context of a clinical trial and it is important to understand whether recent evidence might support its use as an intervention or adjunct to improve arm recovery.

In current clinical practice, robot assisted arm training is not widely available. New technologies are being developed which are potentially more accessible to both in hospital and community services. It is not yet understood the extent to which robot assisted arm training could benefit arm recovery, or indeed whether use of robots may potentially cause harm to the weaker arm following stroke. In addition, there are discrepancies around the use of this technology regarding whether it can be used independently or requires supervision by health care professionals.

Implementation of robot assisted arm training will require investment in training and equipment in the majority of services and review of evidence is necessary to understand both the effectiveness and cost effectiveness of its implementation within stroke rehabilitation services.

1.1.2 Summary of the protocol

Table 1: PICO characteristics of review question

Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after subarachnoid haemorrhage). Exclusion: • Children (age <16 years) • People who had a transient ischaemic attack
Intervention	Robot-assisted arm training (all types pooled together)
Comparison	Any other intervention (including usual care and no treatment – all comparators pooled together) Confounding factors (for non-randomised studies only): • Presence of comorbidities • Stroke severity • Time period since stroke
Outcomes	All outcomes are considered equally important for decision making and therefore have all been rated as critical: At the following time periods:

	• Post-intervention (outcomes reported immediately after the intervention has finished).
	• ≥6 months (the longest time period will be used for this outcome. If the outcome is less than 6 months, then it will be included but downgraded for indirectness).
	• Person/participant generic health-related quality of life (continuous outcomes will be prioritised)
	• Carer generic health-related quality of life (continuous outcomes will be prioritised)
	• Activities of daily living (continuous outcomes will be prioritised)
	• Arm function (continuous outcomes will be prioritised)
	• Arm muscle strength (continuous outcomes will be prioritised)
	• Spasticity (continuous outcomes prioritised)
	• Stroke-specific Patient-Reported Outcome Measures (continuous outcomes will be prioritised)
	• Withdrawal for any reason (dichotomous outcome)
	• Adverse events (dichotomous outcomes)
	  ○ Cardiovascular events
	  ○ Injuries and pain
	  ○ Other reported adverse events

Study design	• Systematic reviews of RCTs
	• Parallel RCTs
	• Cross over trials (only the first study period will be included)
	• Non-randomised studies (if insufficient RCT evidence is available)
	  ○ Prospective cohort studies
	  ○ Retrospective cohort studies
	  ○ Case-control studies
	Published NMAs and IPDs will be considered for inclusion.

For full details see the review protocol in Appendix A.

1.1.3 Methods and process

This evidence review was developed using the methods and process described in Developing NICE guidelines: the manual. Methods specific to this review question are described in the review protocol in Appendix A and the methods document.

Declarations of interest were recorded according to NICE's conflicts of interest policy.

1.1.4 Effectiveness evidence

1.1.4.1 Included studies

One systematic review[79] and in total eighty-one randomised controlled trial studies (one hundred and five papers) were included in the review[1-5, 9-12, 15-21, 24, 25, 27, 28, 31, 34-37, 39-42, 44-51, 53-58, 61, 62, 64-68, 72-74, 77, 82, 84-88, 90, 92-106, 109-112]; these are summarised in Table 2 below. Evidence from these studies is summarised in the clinical evidence summary below (Table 3).

This review updated a previous Cochrane review, Mehrholz 2018[79]. This review included forty-five trials from up to January 2018. A search from January 2018 was completed and an additional thirty trials were added to the review[1, 5, 11, 15-20, 27, 28, 35, 37, 46, 47, 50, 51, 54, 55, 58, 84, 86-88, 92, 93, 97, 103, 110, 112]. This included six cross-over trials (of which only the first phase was included in the analysis as per the Cochrane review protocol)[3, 10, 17, 41, 50, 74].

Trials included comparisons of robot assisted arm therapy to any other intervention (including usual care/conventional rehabilitation, no treatment and other interventions. All comparisons have been pooled for the analysis as in Mehrholz 2018[79].

Robot assisted arm training was usually offered alongside conventional rehabilitation exercises or in two studies as a combination with other therapies (including botulinum toxin A injection and functional electrical stimulation).

Studies included a range of robotic devices which performed different movement types (including active, active/assisted, passive or a combination) and which targeted different parts of the joint (for example: proximal or distal). The type of movement and the region of the limb trained was poorly reported in many studies, but the majority of the robotic devices provided a combination of passive and active assisted movements and trained both the proximal and distal limb to perform tasks such as reaching and grasping. Nearly all of the trials reported supervised robot assisted arm training and the healthcare professional delivering the therapy was most commonly an occupational therapist or physiotherapist.

The people included in the studies were from a mixture of time periods after stroke, being split between subacute and chronic periods. However, the majority of studies included people in the subacute phase post stroke.

Indirectness

7 outcomes were downgraded for indirectness due to outcome indirectness arising from a short follow up duration. Specifically, any outcomes reported after the post intervention follow up were included in the ≥6 month follow up category and if these were reported at less than 6 months they were downgraded.

Inconsistency

A number of outcomes showed significant heterogeneity. In each case, this was not resolved by sensitivity or subgroup analyses and so random effects models were used, and the outcomes were downgraded for inconsistency.

See also the study selection flow chart in Appendix C, study evidence tables in Appendix D, forest plots in Appendix E and GRADE tables in Appendix F.

1.1.4.2 Excluded studies

See the excluded studies list in Appendix J.

1.1.5 Summary of studies included in the effectiveness evidence

Table 2: Summary of studies included in the evidence review

Study	Intervention and comparison	Population	Outcomes	Comments
Abdollahi 2018[1]	**Robot-assisted arm training** (n=12) Three 45-minute sessions per week (six sessions total). Duration 2 weeks. Region of upper limb trained: Not stated/unclear Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=10) Bilateral training without error augmentation Three 45- minute sessions per week (six sessions total). Duration 2 weeks. **Concomitant therapy:** Not reported.	**People after a first or recurrent stroke** Mean age: 53.86 years N = 26 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	Setting: Outpatient rehabilitation hospital in the United States of America. Sources of funding: Not reported.
Abdullah 2011[2]	**Robot-assisted arm training** (n=9) 45 minutes, 3 times a week for 8-11 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Starting with passive and moving up to active assisted	**People after a first or recurrent stroke** Mean age: Not available* N = 20 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=11) Conventional arm therapy 45 minutes, 3 times a week for 8-11 weeks **Concomitant therapy:** not available*			
Amirabdollahian 2007[3] Subsidiary papers: Coote[23] Coote 2003[22]	**Robot-assisted arm training** (n=16) ABC - 3 weeks at baseline (phase A), then 3 weeks robot-mediated therapy (phase B) then 3 weeks sling suspension (phase C). Follow up at 6 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention (conventional arm therapy)** (n=11) Sling suspension. ACB - 3 weeks at baseline (phase A), then 3 weeks sling suspension (phase C), then 3 weeks robot-mediated therapy. Follow up at 6 weeks. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 31 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78]. Crossover study: First time period included only as per the original Cochrane review.

Study	Intervention and comparison	Population	Outcomes	Comments
Ang 2014[4]	**Robot-assisted arm training** (n=15) With the haptic knob robot with and without a brain computer interface. Total of 18 sessions over 6 weeks, 3 times per week, 90 min per session. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=7) Standard arm therapy. Total of 18 sessions over 6 weeks, 3 times per week, 90 min per session. **Concomitant therapy:** therapist-assisted arm mobilisation for 30 minutes.	**People after a first or recurrent stroke** Mean age: Not available* N= 22 Mean time after stroke: Mixed >4 months Subacute and Chronic. Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post intervention and ≥6 months Withdrawal for any reason at post intervention and ≥6 months Adverse events at post intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Aprile 2020[5] Subsidiary papers: Aprile 2021[6] Padua 2020[83]	**Robot-assisted arm training** (n=123) Performed daily for 45 minutes, 5 days a week, for a total of 30 sessions. Region of upper limb trained: Mixed. Level of supervision: Supervised Type of movement delivered by robotic device: Mixed	**People after a first or recurrent stroke** Mean age (SD): 69.0 (11.2) years N = 247 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Person/participant generic health related quality of life at post-intervention Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	Setting: 8 rehabilitation centres of the Fondazione Don Carlo Gnocchi, in Italy. Sources of funding: Not reported.

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=124) Conventional treatment performed daily for 45 minutes, 5 days a week, for a total of 30 sessions. **Concomitant therapy:** Conventional rehabilitation sessions (6 times/week), lasting 45 minutes Occupational and speech therapy were provided, if needed.			
Bishop 2014[9] Subsidiary study: Helbok 2010[38]	**Robot-assisted arm training** (n=16) Robot therapy with the Amadeo Hand robot three times per week for eight weeks, for 60 minutes. Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=15) Standard arm therapy for three times per week for eight weeks, for 60 minutes. **Concomitant therapy:** No additional information.	**People after a first or recurrent stroke** Mean age: Not stated/unclear N = 31 Time after stroke: Chronic (at least 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	Setting: United States of America and Austria. Sources of funding: No additional information. *This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
Brokaw 2014[10]	**Robot-assisted arm training** (n=7) Group AB: 12 hours of robotic training within a month (A) and 12 hours of conventional therapy within a month (B), separated by a month of wash-out period. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=5) Group BA: 12 hours of conventional therapy within a month (B), and 12 hours of robotic training within a month (A) separated by a month of wash-out period. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 12 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78]. Crossover study: First time period included only.
Budhota 2021[11]	**Robot-assisted arm training** (n=22) Robotic therapy with H-Man: 18 training sessions of 60 min each, followed by a 30 min 1:1 conventional therapy session three times a week and over a span of 6 weeks.	**People after a first or recurrent stroke** Mean age (SD): 55.5 (10.7) years N = 44 Median time after stroke (IQR): Intervention: 458 (451.3) days, Control: 390 (327.5) days Ethnicity: Not stated/unclear	Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention	Setting: conducted at the outpatient clinic of the Tan Tock Seng Hospital, Centre for Advanced Rehabilitation Therapeutics (TTSH-CART), Singapore. Sources of funding: Supported by the National Medical Research Council (NMRC, NMRCB2b0006c) Singapore and the

Study	Intervention and comparison	Population	Outcomes	Comments
	Region of upper limb trained: Not stated/unclear. Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=22) Conventional therapy: 18 training sessions of 90 min each, three times a week and over a span of 6 weeks **Concomitant therapy:** None reported.	Severity: Not stated/unclear		H-Man project (NMRC/BnB/0006b/2013), Ministry of Health, Singapore; Ageing Research Institute for Society and Education (ARISE), Singapore: M4082063 and Interdisciplinary Graduate School, Nanyang Technological University, Singapore.
Burgar 2011[12]	**Robot-assisted arm training** (n=36) 15 x1 hour therapy sessions over a 3-week period (1 robot group received 30 1- hour therapy sessions over 3- week period). Region of upper limb trained: Proximal Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=18) 15 x1 hour therapy sessions over a 3-week period **Concomitant therapy:** None reported.	**People after a first or recurrent stroke** Mean age (SD): Not available* N = 54 Mean time after stroke: 11 days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months. Arm function at post-intervention and ≥6 months. Arm muscle strength at post-intervention and ≥6 months. Spasticity at post-intervention and ≥6 months. Withdrawal for any reason at post- intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
Calabro 2019[15]	**Robot-assisted arm training** (n=25) 40 hand training sessions of 45 minutes each, 5 times a week, for 8 consecutive weeks. Region of upper limb trained: Not stated/ unclear Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=25) 40 hand training sessions of 45 minutes each, 5 times a week, for 8 consecutive weeks. **Concomitant therapy:** The patients were asked not to undertake other physiotherapy treatments during the 8-week training period.	**People after a first or recurrent stroke** Mean age (SD): 64.5 (3.0) years N = 50 Mean time after stroke (SD): 10 (2) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: In-patient, at the Neuro-robotic Rehabilitation Unit of the IRCCS Centro Neurolesi Bonino Pulejo, Italy. Sources of funding: No funding.
Carpinella 2020[16] Subsidiary paper: Lencioni 2021[60]	**Robot-assisted arm training** (n=20) Using a planar robotic manipulandum 20 sessions of 45 minutes each, 5 times a week. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic	**People after a first or recurrent stroke** Median age (IQR): Intervention: 67 (58 to 70) years Control: 59 (46 to 69) years N = 40 Median time after stroke (IQR): intervention: 7 (1.7 to 11.9) months, control: 5.3 (1.9 to 89.6) months	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: 2 stroke rehabilitation hospitals in Italy. Sources of funding: supported by the Italian Ministry of Health (Ricerca Corrente and Ricerca Finalizzata: grant no. GR-2011-02348942).

Study	Intervention and comparison	Population	Outcomes	Comments
	device: Active assisted movement **Any other intervention** (n=20) Usual care arm-specific physiotherapy 20 sessions of 45 minutes each, 5 times a week. **Concomitant therapy:** Participants in both groups received a rehabilitation treatment for the affected upper limb consisting of 20 sessions of 45 min each, 5 times a week by trained physiotherapists.	Ethnicity: Not stated/unclear Severity: Mild (or NIHSS 1-5)		
Chen 2022[17]	**Robot-assisted arm training** (n=16) Hand of Hope robotic hand system. 12 sessions of robot-assisted intervention first, followed by a 1-month washout period, then 12 sessions (3 sessions per week for 4 consecutive weeks) of task-oriented interventions. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed	**People after a first or recurrent stroke** Mean age (SD): 59.6 (11.0) years N = 31 Mean time after stroke (SD): 48.1 (40.6) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: Outpatient follow-up in Taiwan. Sources of funding: This study was supported by Chang Gung Memorial Hospital (BMRP553, CMRPD1I0033), the Ministry of Science and Technology (MOST 109-2314-B-192-027-MY3) and Healthy Aging Research Center, Chang Gung University from the Featured Areas Research Center Program within the Framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan (EMRPD1L0411). Crossover study: First time period only included.

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=15) Usual care. Task-oriented interventions. 12 sessions (3 sessions per week for 4 consecutive weeks). After which they had a 1-month washout period and then participated in 12 sessions of robot assisted arm training. **Concomitant therapy:** No additional information.			
Chen 2021[18]	**Robot-assisted arm training** (n=10) (Armule®, Intelbot intelligent machine Co., Ltd, Wuhan, China) 45 minutes daily, 5 days/week for 4 weeks. Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=10) Conventional therapy 45 min daily, 5 days/week for 4 weeks. **Concomitant therapy:** Conventional rehabilitation programs continued as usual for all participants.	**People after a first or recurrent stroke** Mean age (SD): 47.4 (8.47) years N = 20 Mean time after stroke (SD): 91.8 (74.2) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: Department of Rehabilitation Medicine, China. Sources of funding: received financial support for the research and publication of this article from National Natural Science Foundation of China (U 1913601 and No. 91648203). This study is reported in forest plots as Chen 2021A.

Study	Intervention and comparison	Population	Outcomes	Comments
Chen 2021[19]	**Robot-assisted arm training** (n=10) Exoskeleton-assisted anthropomorphic movement training 45 min daily, 5 days/week for 4 weeks. Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=10) Conventional therapy 45 min daily, 5 days/week for 4 weeks. **Concomitant therapy:** All participants received routine multidisciplinary treatment, including medication and usual poststroke care.	**People after a first or recurrent stroke** Mean age (SD): 51 (13.5) years N = 20 Mean time after stroke (SD): 62.5 (48.7) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	This study is reported in forest plots as Chen 2021B. Setting: Department of Rehabilitation Medicine in China. Sources of funding: Supported by the National Natural Science Foundation of China (grant nos. U 1913601, 91648203).
Chinembiri 2021[20]	**Robot-assisted arm training** (n=25) Robot and occupational therapy. 50-70 minutes per day, 5 days a week for 6 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Mixed	**People after a first or recurrent stroke** Mean age (SD): 57.5 (8.4) years N = 50 Mean time after stroke: Not stated/unclear Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: Outpatients in China. Sources of funding: Supported by the Jiangsu Provincial Medical Youth Talent under Grant (number QNRC2016376).

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=25) Usual care. Training involving self-range of motion and passive stretch exercises for the shoulder, elbow, wrist and thumb joints, and muscles (five sets of repetitions) for the first 10 minutes, then a larger selection of upper limb exercises for the next 40 minutes. **Concomitant therapy:** Both groups received 30 training sessions lasting 50 minutes per day (for the control group and lower end of the intervention group), 5 days a week for a total of 6 weeks.			
Conroy 2011[21]	**Robot-assisted arm training** (n=41) Over 6 weeks, 3 sessions per week for 1 hour. Region of upper limb trained: Not stated/unclear Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Active assisted movement **Any other intervention** (n=21) Intensive conventional arm exercise.	**People after a first or recurrent stroke** Mean age: not available* N = 62 Mean (SD) time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Not available*			
Coskunsu 2022[24]	**Robot-assisted arm training** (n=12) 1 hour, 5 days per week for 3 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=12) Usual care. **Concomitant therapy:** Everyone received rehabilitation exercises (including physiotherapy) for 1 hour (30 minutes for the upper extremity, 30 minutes for the lower extremity).	**People after a first or recurrent stroke** Mean age (SD): 65.0 (15.0) years N = 24 Time after stroke: Subacute (7 days – 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: Inpatients in Turkey Funding: Supported by the Rehab Robotic Company.
Daly 2005[25]	**Robot-assisted arm training** (n = 7) 5 hours per day, 5 days per week for 12 weeks. 1.5 hours per day for robotic shoulder and elbow training. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic	**People after a first or recurrent stroke** Mean age: Not available* N = 13 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	device: Active assisted movement **Any other intervention** (n=6) 5 hours per day, 5 days per week for 12 weeks. 1.5 hours per day for functional electrical stimulation. **Concomitant therapy:** Not available*			
Daunoravicienе 2018[27]	**Robot-assisted arm training** (n=17) Armeo Spring training for 30 minutes a day for 10 sessions (5 days a week). Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=17) 30 minutes on 5 days a week of conventional functional rehabilitation. **Concomitant therapy:** Conventional functional rehabilitation for 35-60 minutes/day in approximately 10 occupational therapy sessions.	**People after a first or recurrent stroke** Mean age (SD): 65.7 (4.5) years N = 34 Mean time after stroke (SD): 9.1 (5.1) weeks Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Spasticity at post-intervention	Setting: Outpatients in Lithuania. Sources of funding: No additional information.
Dehem 2019[28]	**Robot-assisted arm training**	**People after a first or recurrent stroke**	Arm function at post-intervention and at ≥6 months	Setting: Three inpatient rehabilitation

Study	Intervention and comparison	Population	Outcomes	Comments
	(n=23) REAplan(R) robot arm therapy. 45 minutes sessions supervised by a therapist. 4 sessions of conventional therapy per week was replaced and was completed for 9 weeks in total. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Active assisted movement **Any other intervention** (n=22) Conventional therapy focused on motor rehabilitation, matched with their personal needs and centre means. **Concomitant therapy:** Both groups underwent their rehabilitation sessions during their hospitalisation with their regular physical therapists and occupational therapists.	Mean age (SD): 67.9 (15.5) years N = 45 Mean time after stroke (SD): Not reported Ethnicity: Not stated/unclear Severity: Not stated/unclear	Stroke-specific Patient-Reported Outcome Measures at post-intervention and at ≥6 months Withdrawal for any reason at post-intervention and at ≥6 months Adverse events at post-intervention and at ≥6 months	centres: Cliniques universitaries Saint-Luc (Brussels), Centre Hospitalier Valida (Brussels) and Centre Hospitalier Neurologique William Lennox (Ottignies) in Belgium. Sources of funding: This work was supported by the Region Wallone, the Fondation Motrice and the Fondation Saint-Luc. The authors thank Axinesis (Wavre, Belgium) for development of the robot REAplan and Fishing Cactus (Mons, Belgium) for development of the game.
Fazekas 2007[31]	**Robot-assisted arm training** (n=15) 30 minutes of Bobath therapy sessions on 20 consecutive days, plus an additional 30 minutes of robot therapy.	**People after a first or recurrent stroke** Mean age: Not available* N = 30 Time after stroke: Chronic (>6 months) Ethnicity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Passive **Any other intervention** (n=15) 30 minutes of Bobath therapy sessions on 20 consecutive days. **Concomitant therapy:** Not available*	Severity: Not stated/unclear		
Frisoli 2022[34]	**Robot-assisted arm training** (n=13) Robot therapy for 45 minutes, 3 times a week for 6 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active assisted movement **Any other intervention** (n=13) Manual rehabilitation including passive movement, goal directed movement and voluntary action for a matched amount of time. **Concomitant therapy:** No additional information	**People after a first or recurrent stroke** Mean age (SD): 66 (12) years N = 26 Mean time after stroke (SD): 34 (22) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	Setting: Outpatient follow up in Italy. Funding: Partially funded by SKILLS EU FP7 project. One author is funded by a postgraduate fellowship.

Study	Intervention and comparison	Population	Outcomes	Comments
Gandolfi 2019[35]	**Robot-assisted arm training** (n=16) Passive mobilisation and stretching exercises for the affected upper limb (10 minutes) followed by robot-assisted exercises (35 minutes). 2 sessions per week for 5 consecutive weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=16) Conventional training consisting of upper limb passive mobilisation and stretching (10 minutes) followed by upper limb exercises (35 minutes), 2 sessions per week for 5 consecutive weeks. **Concomitant therapy:** All people received botulinum toxin A treatment. The dose, volume and number of injection sites were set according to the severity of spasticity.	**People after a first or recurrent stroke** Mean age (SD): 59.2 (14.7) years N = 32 Mean time after stroke (SD): 5.6 (2.7) years Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	Setting: People referred to the Neurorehabilitation Unit (AOUI Verona) and the Physical Medicine and Rehabilitation Section, "OORR" Hospital (University of Foggia) in Italy. Sources of funding: No additional information.
Grigoras 2016[36]	**Robot-assisted arm training** (n=13)	**People after a first or recurrent stroke**	Arm function at post-intervention Stroke-specific Patient-Reported Outcome	*This study was included in the original Cochrane review that was updated in this

Study	Intervention and comparison	Population	Outcomes	Comments
	With hybrid FES exoskeleton system for hand rehabilitation. 12 sessions of 30 minutes for 2 weeks. Region of upper limb trained: Distal Level of supervision: Supervised Type of movement delivered by robotic device: Active assisted movement **Any other intervention** (n=12) 10 sessions of standard arm therapy (30 minutes for 2 weeks.) **Concomitant therapy:** No information*	Mean age: No information* N = 25 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Measures at post-intervention Withdrawal for any reason at post-intervention	review. For further details see Mehrholz 2018[78].
Gueye 2021[37]	**Robot-assisted arm training** (n=25) Virtual reality robot-assisted arm therapy using an Armeo Spring device: 45 minute sessions for 12 sessions over a three week period (4 sessions per week). Region of upper limb trained: Not stated/unclear Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear	**People after a first or recurrent stroke** Mean age (SD): 67.3 (12.1) years N = 50 Mean time after stroke (SD): 15.6 (6.9) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: outpatients at the Stroke Rehabilitation Unit of the General University Hospital in Prague in the Czech Republic. Sources of funding: No additional information.

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=25) Usual care. An additional 45 minutes of physiotherapy for 12 sessions over a three week period (4 sessions per week). **Concomitant therapy:** The programme consists of at least 3-4 hours of activity which includes one hour of physiotherapy twice a day, occupational therapy, therapies using passive or motor splints and individual or group therapy for speech and cognitive impairment.			
Hesse 2014[39]	**Robot-assisted arm training** (n=25) Robot-assisted group therapy for 30 minutes plus individual arm therapy for 30 minutes, each workday for 4 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=25) Individual arm therapy for 2 x 30 minutes each	**People after a first or recurrent stroke** Mean age: Not available* N = 50 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	workday for 4 weeks. **Concomitant therapy:** Not available*			
Hesse 2005[40]	**Robot-assisted arm training** (n=22) Therapy with Bi-Manu Track robotic arm trainer 5 times a week for 6 weeks. Region of upper limb trained: Distal limb Level of supervision: Unsupervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=22) Functional electrical stimulation (if possible EMG-initiated) for wrist extension 5 times a week for 6 weeks. **Concomitant therapy:** Standard rehabilitation programme.	**People after a first or recurrent stroke** Mean age: Not available* N = 44 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Hollenstein 2011[41]	**Robot-assisted arm training** (n=7) With the Armeo device 5 times a week for 30 minutes over 2 weeks (10 times). Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear	**People after a first or recurrent stroke** Mean age: not available* N = 13 Mean time after stroke: Not stated/unclear Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78]. Crossover study: first time period only included.

Study	Intervention and comparison	Population	Outcomes	Comments
	Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=6) Arm group programme. Without device delivered by an occupational therapist for the same time and frequency as the robot therapy group. **Concomitant therapy:** Not available*			
Housman 2009[42]	**Robot-assisted arm training** (n=17) With T-WREX device 3 times a week for 1 hour over 8-9 weeks. Region of upper limb trained: Proximal limb Level of supervision: Mixed Type of movement delivered by robotic device: Passive movement **Any other intervention** (n=17) As above, but without the device. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 34 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Hsieh 2014[44] Subsidiary paper:	**Robot-assisted arm training** (n=32) robot-assisted arm therapy (Bi-Manu-Track) with and	**People after a first or recurrent stroke** Mean age: Not available* N = 48	Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further

Study	Intervention and comparison	Population	Outcomes	Comments
Hsieh 2016[43]	without constraint-induced therapy- 20 training sessions of 90 to 105 min/day, 5 days/ week for 4 weeks. Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed **Any other intervention** (n=16) Conventional therapy- 20 training sessions of 90 to 105 min/day, 5 days/ week for 4 weeks. **Concomitant therapy:** Not available*	Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear		details see Mehrholz 2018[78].
Hsieh 2011[45]	**Robot-assisted arm training** (n=12) High/low intensity robot training with Bi-Manu Track. 20 training sessions for 90 to 105 minutes, 5days per week for 4 weeks. Participants also received 15-20 minutes of functional activities training. Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed	**People after a first or recurrent stroke** Mean age: not available* N = 18 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=6) Participants received a structured protocol using conventional occupational therapy techniques. **Concomitant therapy:** Not available*			
Hsu 2019[46]	**Robot-assisted arm training** (n=22) With Bi-Manu Track three times per week for four weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=21) 40 minutes of therapist-facilitated task-specific training for the affected limb. **Concomitant therapy:** All people received a 10-minute per-protocol sensorimotor stimulation session prior to the interventions as part of usual care.	**People after a first or recurrent stroke** Mean age (SD): 52.9 (13.2) years N = 43 Mean time after stroke (SD): 14.2 (11.1) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention and ≥6 months	Setting: Outpatients in Taiwan. Sources of funding: This work was supported by Chi Mei Medical Center and National Cheng Kung University under grant #CMNCKU10304. This work was also financially supported by the Medical Device Innovation Center, National Cheng Kung University from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan.
Hsu 2021[47]	**Robot-assisted arm training** (n=17) An additional 20-minutes of robot-	**People after a first or recurrent stroke** Mean age (SD): 55.9 (15.0) years	Arm function at post-intervention and ≥6 months	Setting: Outpatients in Taiwan. Sources of funding: Financially supported

Study	Intervention and comparison	Population	Outcomes	Comments
	assisted arm training using TIGER (Tenodesis-induced-grip exoskeleton robot) Two sessions of training a week for 9 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=17) An additional 20-minutes of task-specific motor training through regular occupational therapy. **Concomitant therapy:** All people received 20-minutes of regular task-specific motor training.	N = 34 Mean time after stroke (SD): 30.0 (24.5) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention and ≥6 months	by the Medical Device Innovation Center, National Cheng Kung University, from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan. This project was supported in part by the Ministry of Science and Technology, Taiwan, under Grant MOST 108-2745-8-006-009 and in part by the National Cheng Kung University Hospital, Tainan, Taiwan under Grant NCKUH 10708003.
Hung 2022[48]	**Robot-assisted arm training** (n=13) 75 minutes of training, 3 times a week for 8 weeks, with 45 minutes of the training being with a robot, and 30 minutes being functional activities practice. Region of upper limb trained: Mixed Level of supervision: Supervised	**People after a first or recurrent stroke** Mean age (SD): 47.3 (11.5) years N = 37 Mean time after stroke (SD): 34.8 (22.0) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months	Setting: Outpatients in Taiwan. Funding: Government or Academic funding.

Study	Intervention and comparison	Population	Outcomes	Comments
	Type of movement delivered by robotic device: Mixed **Any other intervention** (n=24) Two groups combined. One received mirror therapy for 45 minutes and 30 minutes of functional activities practice. The other received conventional task-oriented practice for 45 minutes, and 30 minutes of functional activities practice. **Concomitant therapy:** All people received an injection of botulinum toxin. All other routine rehabilitation that did not involve upper extremity training proceded as usual.			
Hwang 2012[49]	**Robot-assisted arm training** (n=9) 4 weeks (20 sessions) of active robot-assisted intervention with Amadeo (full-term intervention). Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear	**People after a first or recurrent stroke** Mean age: Not available* N = 15 Mean time after stroke (SD): 6.5 (5.3) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Stroke-specific Patient Reported Outcome Measure at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=5) 2 weeks (10 sessions) of early passive therapy, followed by 2 weeks (10 sessions) of active robot-assisted intervention (the half term intervention) group. Data from the first 2 weeks of intervention were used. **Concomitant therapy:** Not available*			
Iwamoto 2019[50]	**Robot-assisted arm training** (n =6) Hybrid Assistive Limb 40 minutes per day for 6 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted. **Any other intervention** (n=6) Occupational therapy for 6 weeks. **Concomitant therapy:** The total time of combination therapy during A and occupational therapy during B was equivalent. In the current Japanese medical	**People after a first or recurrent stroke** Mean age (SD): 61.0 (18.9) years N = 12 Mean time after stroke: Not stated/unclear Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm muscle strength living at post-intervention	Setting: Inpatient rehabilitation department of neurosurgical hospital. Sources of funding: Not reported. Crossover study: First time period included only.

Study	Intervention and comparison	Population	Outcomes	Comments
	system, the medical doctor prescribes a rehabilitation programme, and rehabilitation therapists (occupational therapist, physiotherapist, and speech therapist) design individually tailored exercise programmes for acute stroke patients for up to 3 hours per day.			
Jiang 2021[51]	**Robot-assisted arm training** (n=23) Robot therapy (Armeo Spring) for 30 minutes twice a day, for 2 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=22) Conventional rehabilitation for 30 minutes twice a day, for 2 weeks. **Concomitant therapy:** All received conventional rehabilitation therapy for 30 minutes twice a day, for 2 weeks.	**People after a first or recurrent stroke** Mean age (SD): 64.2 (11.5) years N = 45 Mean time after stroke (SD): 19.8 (6.3) days Ethnicity: Not stated/unclear Mean severity (SD) – NIHSS: 6.1 (1.8)	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months	Setting: Inpatient rehabilitation ward in China. Sources of funding: Supported by a fund from the Lanzhou Science and Technology Bureau (document number: 2016-2-59).
Kahn 2006[53]	**Robot-assisted arm training** (n=10)	**People after a first or recurrent stroke** N= 19	Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was

Study	Intervention and comparison	Population	Outcomes	Comments
Subsidiary paper: Kahn 2001[52]	8-week therapy programme involving 24 sessions, each lasting 45 minutes. Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=9) 'Free reaching training' in an 8 week therapy programme involving 24 sessions, each lasting 45 minutes. **Concomitant therapy:** Not available*	Mean age (SD): 64.1 (11.5) years Mean time after stroke (SD): 19.8 (6.3) days Ethnicity: Not stated/unclear Mean severity (SD) – NIHSS: 6.1 (1.8)		updated in this review. For further details see Mehrholz 2018[78].
Kim 2021[18]	**Robot-assisted arm training** (n=23) Electromechanically assisted upper limb training using Camillo for 30 minutes a day, 5 days a week for 4 weeks. Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention**	**People after a first or recurrent stroke** Mean age (SD): 59.7 (14.0) years N = 47 Mean time after stroke (SD): 582.9 (1010.1) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Person/participant generic health-related quality of life at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: Outpatients in the Republic of Korea. Sources of funding: Supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI15C1529). Device support from Man&Tel Co. Ltd, Gumi, Republic of Korea.

Study	Intervention and comparison	Population	Outcomes	Comments
	(n=24) Occupational therapist-assisted upper limb training for 30 minutes a day, 5 days a week for 4 weeks. **Concomitant therapy:** All people underwent additional therapy for activities of daily living for 30 minutes daily during the study period.			
Kim 2019[69]	**Robot-assisted arm training** (n=19) Robot-assisted shoulder rehabilitation therapy for 30 minutes per day, 5 times per week for a total of 20 sessions for 4 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=19) Conventional rehabilitation only **Concomitant therapy:** all participants received usual care.	**People after a first or recurrent stroke** Mean age (SD): 65.3 (8.9) years N = 38 Mean time after stroke (SD): 3.3 (0.9) months Ethnicity: Not stated/unclear Mean severity (SD) – NIHSS: 9.2 (2.5)	Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention and ≥6 months	Setting: Outpatients in the Republic of Korea. Sources of funding: Support by Wonkwang Institute of Clinical Medicine (2016-0669), Republic of Korea.
Kutner 2010[56]	**Robot-assisted arm training** (n=10)	**People after a first or recurrent stroke**	Stroke-specific Patient Reported Outcome at post-intervention and	*This study was included in the original Cochrane review that was

Study	Intervention and comparison	Population	Outcomes	Comments
	30 hours of repetitive task training plus 30 hours of robotic assisted training over 3 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=11) 60 hours of repetitive task training over 3 weeks. **Concomitant therapy:** Not available*	Mean age (SD): Not available* N = 21 Time after stroke: Mixed (3-9 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	≥6 months Measure Withdrawal for any reason at post-intervention Adverse events at post-intervention	updated in this review. For further details see Mehrholz 2018[78].
Lee 2016[57]	**Robot-assisted arm training** (n=29) With the robot Neuro-X over 20 sessions (30 minutes per session, 2 sessions per day, 5 days a week for 2 weeks). Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=29) Conventional upper extremity	**People after a first or recurrent stroke** Mean age (SD): Not available* N = 58 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	rehabilitation exercise twice daily. **Concomitant therapy:** Not available*			
Lee 2018[58]	**Robot-assisted arm training** (n=15) 5, 30 min sessions REJOYCE robot treatment per week for 8 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=15) 5, 30 min sessions of general occupational therapy per week for 8 weeks. **Concomitant therapy:** Both groups received general occupational therapy consisting of 5, 30 min sessions per week for 8 weeks.	**People after a first or recurrent stroke** Mean age (SD): 51.2 (12.7) years N = 30 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: Rehabilitation hospital in Korea. Sources of funding: Not reported.
Liao 2012[61] Subsidiary paper: Hsieh 2011[45]	**Robot-assisted arm training** (n=10) With Bi-Manu - Track over 4 weeks, 5 days a week for 90 to 105 minutes per session. After robot training, participants received 15 minutes of training	**People after a first or recurrent stroke** Mean age: not available* N = 20 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	in functional activities. Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed **Any other intervention** (n=10) Protocol-based occupational therapy techniques. The control group received the same amount of therapy hours as the treatment group; after the active control therapy session the participants also received 15 minutes of training in functional activities. **Concomitant therapy:** Not available*	Severity: Not stated/unclear		
Lin 2022[62]	**Robot-assisted arm training** (n=86) Robot training for 30 minutes, 5 days a week for 3 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=86)	**People after a first or recurrent stroke** Mean age (SD): 59.0 (12.0) years N = 172 Mean time after stroke (SD): 158.3 (170.9) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Activities of daily living at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: Outpatients in China. Funding: Government or academic funding.

Study	Intervention and comparison	Population	Outcomes	Comments
	Enhanced occupational therapy that was time matched. **Concomitant therapy:** All people received conventional rehabilitation, 5 days a week for 3 weeks divided into 30 minutes of physiotherapy and occupational therapy respectively.			
Lo 2010[64]	**Robot-assisted arm training** (n=49) Maximum of 36 sessions over 12 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=78) Intensive comparison therapy which matched the robot therapy in schedule and in form of intensity of movements. (n=50) Customary care (i.e. medical management, clinic visits needed and in some cases, rehabilitation services). (n=28) These groups were collapsed into one control group in analysis	**People after a first or recurrent stroke** Mean age: Not available* N = 127 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Spasticity at post-intervention Stroke-specific Patient Reported Outcome Measure at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Not available*			
Lum 2002[65] Subsidiary papers: Burgar 1999[13] Burgar 2000[14]	**Robot-assisted arm training** (n=15) Received bimanual and passive robot therapy by the MIME robot as per the control group. Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=15) Received 55 minutes of physiotherapy for the arm and 5 minutes of robot training for each of the 24 sessions over a 2 month period. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: not available* N = 30 Time after stroke: Chronic (≥6 months) Ethnicity: not stated/ unclear Severity: not stated/ unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Lum 2006[66]	**Robot-assisted arm training** (n=24) Unilateral/ bilateral or combined robot therapy, one hour per day for 6 weeks. Region of upper limb trained: proximal Level of supervision: Not stated/unclear Type of movement delivered by robotic device: mixed	**People after a first or recurrent stroke** Mean age: not available* N = 30 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=6) Received an equivalent intensity and duration of conventional therapy. **Concomitant therapy:** Not available*			
Ma 2022[67]	**Robot-assisted arm training** (n=13) Robot therapy for 60 minutes, 5 days a week for 4 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=13) 60 minutes of one-on-one conventional therapy for unilateral hand functional training. **Concomitant therapy:** All people received 30 minutes of regular conventional therapy, 5 days a week for 4 weeks.	**People after a first or recurrent stroke** Mean age (SD): 57.7 (9.8) years N = 26 Mean time after stroke (SD): 10.2 (6.1) weeks Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention	Setting: Inpatients in Taiwan. Funding: Government or academic funding.
Marganska 2014[68]	**Robot-assisted arm training** (n=39) Robotic therapy with ARMin. Therapy was given 3 times a week for	**People after a first or recurrent stroke** Mean age: not available* N = 77	Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	a period of 8 weeks (sum of 24 sessions). Minimum session time was 45 minutes. Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=38) Conventional therapy 3 times a week for a period of 8 weeks (sum of 24 sessions). Minimum session time was 45 minutes. **Concomitant therapy:** Not available*	Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	
Masiero 2011[72] Subsidiary papers: Masiero 2012[70] Masiero 2014[71]	**Robot-assisted arm training** (n=11) Received robotic training with the NeReBot, twice a day for 20 minutes, and 40 minutes conventional training, 5 days a week for at least 5 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear	**People after a first or recurrent stroke** Mean age: Not available* N = 21 Time after stroke: Mixed (within 20 days of stroke) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=10) 80 minutes per day (including proprioceptive exercises, functional re-education, gait training, occupational therapy, and passive and active-assisted mobilisation of the hand and wrist) but without specifically exercising the proximal paretic arm. **Concomitant therapy:** Not available*			
Masiero 2007[73]	**Robot-assisted arm training** (n =17) Received additional early sensorimotor robotic training with the NeReBot, robot training twice a day, 5 days a week for at least 5 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=18) Received similar exposure to the robot (30 minutes twice per week) except that the exercises were	**People after a first or recurrent stroke** Mean age: not available* N = 35 Time after stroke: Acute (72 hours - 7 days) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	performed with the unimpaired arm. **Concomitant therapy:** Not available*			
Mayr 2008[74]	**Robot-assisted arm training** (n=4) group AB: the participants received over 2 weeks, 5 times per week robot-assisted therapy with the ARMOR device, then 2 weeks with no intervention, and then over 2 weeks, 5 times per week EMG-initiated functional electrical stimulation. Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=4) Functional electrical stimulation. group BA: the participants received 5 times per week over 2 weeks EMG-initiated functional electrical stimulation, then 2 weeks no intervention, and then 5 times per week over 2 weeks robot-assisted therapy.	**People after a first or recurrent stroke** Mean age: not available* N = 8 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78]. Crossover study: First time period included only.

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Not available*			
McCabe 2015[77] Subsidiary paper: Daly 2010[26]	**Robot-assisted arm training** (n=12) Motor Learning Programme in a 1:3 group paradigm for 3.5 hours per day + robotic-assisted arm training with the InMotion2 Shoulder-Elbow Robot 1.5 hours per day for 12 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Not stated/unclear **Any other intervention** (n=27) Motor Learning Programme in a 1:3 group paradigm for 3.5 hours per day + functional electrical stimulation for1.5 hours per day for 12 weeks. Motor Learning Programme in a 1:3 group paradigm for 5 hours per day for 12 weeks. The 2 groups were combined for analysis. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: not available* N = 39 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Orihuela-Espina 2016[82]	**Robot-assisted arm training** (n=9)	**People after a first or recurrent stroke**	Arm function at post-intervention	*This study was included in the original Cochrane

Study	Intervention and comparison	Population	Outcomes	Comments
	Robot therapy with the Amadeo (Inc. Typromotion) for 40 sessions 5 times a week for about 60 minutes. Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed **Any other intervention** (n=9) Classic occupational therapy 40 sessions 5 times a week for about 60 minutes. **Concomitant therapy:** Not available*	Mean age: not available* N = 17 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	review that was updated in this review. For further details see Mehrholz 2018[78].
Park 2021[84]	**Robot-assisted arm training** (n=12) 20 sessions (five days a week for four weeks) of robot-assisted hand training using the Amadeo Robotic device (Trymotion GmbH, Graz, Austria) Region of upper limb trained: Distal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Passive **Any other intervention**	**People after a first or recurrent stroke** Mean age (SD): 70.3 (4.2) years N = 24 Mean time after stroke (SD): 9.3 (2.4) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	Setting: Rehabilitation hospital in South Korea Sources of funding: This work was supported by the Soonchunhyang University Research Fund. This work was supported by the Korea Institute for Advancement of Technology(KIAT) grant funded by the Korea Government(MOTIE) (P0012724, The Competency Development Program for Industry Specialist)

Study	Intervention and comparison	Population	Outcomes	Comments
	(n=12) 20 sessions of conventional treatments that lasted 30 minutes each session **Concomitant therapy:** Not available*			
Rabadi 2008[85]	**Robot-assisted arm training** (n=10) Standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of robotic-assisted arm training with the MIT-Manus 5 days per week. Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed **Any other intervention** (n=20) Group 1: standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of occupational therapy 5 days per week. Group 2: standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of arm ergometry 5 days	**People after a first or recurrent stroke** Mean age: Not available* N = 30 Time after stroke Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	per week. The 2 groups were combined for analysis. **Concomitant therapy:** Not available*			
Ranzani 2020[86]	**Robot-assisted arm training** (n=17) 45 minute sessions, for 6 weeks duration. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=16) Usual care. **Concomitant therapy:** Both groups received conventional neurocognitive therapy sessions that included two or three exercises depending on the session duration (i.e., 30 or 45 min).	**People after a first or recurrent stroke** Mean age (SD): 68.8 (12.2) years N = 33 Mean time after stroke (SD): 3.1 (1.4) weeks Ethnicity: Not stated/unclear Mean severity (SD) - NIHSS: 1.52 (0.91)	Arm function at post-intervention and ≥6 months Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months	Setting: Rehabilitation centre in Switzerland. Sources of funding: This work was supported by the National Center of Competence in Research on Neural Plasticity and Repair of the Swiss National Science Foundation (NCCR Neuro), the ETH CHIRP1 Research Grant on Cortically-Driven Assistance Adaptation during Sensorimotor Training, the Olga Mayenfisch Stiftung, the ETH Zurich Foundation in collaboration with Hocoma AG, and the Clinica Hildebrand Centro di Riabilitazione Brissago, Switzerland.
Remy-Neris 2021[50]	**Robot-assisted arm training** (n=107) Robotic training with ArmeoSpring exoskeleton device. Duration 6 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised	**People after a first or recurrent stroke** Mean age (SD): 58.3 (13.7) years. N = 215 Mean time after stroke (SD): 54.8 (22.2) days Ethnicity: Not stated/unclear	Person/participant health related quality of life at post-intervention and ≥6 months Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Stroke-specific Patient Reported Outcome	Setting: 21 inpatient rehabilitation centres in France. Sources of funding: This study was supported by the French Ministry of Health: EMREM_AVC CHU BREST 20 220.

Study	Intervention and comparison	Population	Outcomes	Comments
	Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=108) Self-rehabilitation. Duration 6 weeks. **Concomitant therapy:** Usual rehabilitation for all participants, followed by an additional daily hour of self-rehabilitation (two 30-minute sessions)	Mean severity (SD) - NIHSS: 5.2 (2.4)	Measure at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention	
Rodgers 2019[88] Subsidiary papers: Rodgers 2020[89] Fernandez-Garcia 2021[32]	**Robot-assisted arm training** (n=257) Training with MIT-Manus robotic gym. 45 min of face-to-face therapy, three times per week for 12 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=513) Repetitive functional task practice or usual care. 45 min of face-to-face therapy, three times per week for 12 weeks.	**People after a first or recurrent stroke** Mean age (SD): 60.6 (13.5) years N = 770 Median time after stroke (IQR): 233 (102 to 549) days Ethnicity: Not stated/unclear Mean severity (SD): 5.7 (3.2)	Person/participant health related quality of life at post-intervention and ≥6 months Activities of daily living at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Stroke-specific Patient Reported Outcome Measure at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention	Setting: Four National Health Service (NHS) centres in the UK. Each centre comprised a stroke service in an NHS hospital with an MIT-Manus robotic gym system (InMotion commercial version, Interactive Motion Technologies, Watertown, MA, USA), plus stroke services in adjacent NHS Trusts and community services. Sources of funding: National Institute for Health Research Health Technology Assessment Programme.

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Usual post-stroke care.			
Sale 2014[90] Subsidiary papers: Franceschi 2020[33] Mazzoleni[75] Mazzoleni[76] Sale 2014[91]	**Robot-assisted arm training** (n=26) 30 sessions of robot-assisted therapy (5 days a week for 6 weeks). Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=27) Conventional rehabilitative treatment 30 sessions (5 days a week for 6 weeks) **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 53 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Singh 2021[92]	**Robot-assisted arm training** (n=13) Robot therapy sessions were conducted for 45 min per day for 5 days a week for 4 weeks. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted	**People after a first or recurrent stroke** Mean age (SD): 41.9 (11.2) years N = 23 Mean time after stroke (SD): 12.0 (7.5) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	Setting: Outpatient clinic in India. Sources of funding: financially supported by SERB, DST India (YSS/2015/000697) and IIT Delhi, MFIRP (Project no. AI-19).

Study	Intervention and comparison	Population	Outcomes	Comments
	Any other intervention (n=14) The conventional therapy session was conducted for 45 min per day for 5 days a week for 4 weeks. **Concomitant therapy:** No additional information.			
Straudi 2020[93]	**Robot-assisted arm training** (n=20) 1 hour and 40 minutes of hand functional electrical stimulation + robot-assisted arm therapy for each session (5 times/week over 6 weeks). Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=20) 1 hour and 40 minutes of conventional therapy (5 times/week over 6 weeks). **Concomitant therapy:** In addition to arm rehabilitation, all patients received multidisciplinary rehabilitation based on an individualized approach.	**People after a first or recurrent stroke** Median age (IQR): Intervention: 68 (56 to 71) years Control: 68 (58.5 to 73) years N = 40 Median time after stroke (IQR): Intervention: 39 (21 to 62) days Control: 32.5 (20 to 51) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	Setting: Inpatient Rehabilitation at a University Hospital in Italy. Sources of funding: Not reported.

Study	Intervention and comparison	Population	Outcomes	Comments
Susanto 2015[94]	**Robot-assisted arm training** (n=9) Hand exoskeleton robot-assisted training for 10 1-hour sessions. Duration 5 weeks Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=10) Non-assisted training, 20 1- hour sessions for 5 weeks. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 19 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Takebayashi 2022[96]	**Robot-assisted arm training** (n=87) Two groups combined. One group (n=44) received robot therapy and therapist led occupational therapy for 20 minutes. One group (n=43) received robot therapy and therapist led constrain induced movement therapy. Robot therapy was for 40 minutes, 3 days a week for 10 weeks. Region of upper limb trained: Proximal limb	**People after a first or recurrent stroke** Mean age (SD): 59 (11) years N = 129 Mean time after stroke (SD): 36.6 (51.3) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Stroke-specific Patient-Reported Outcome Measures at post-intervention Withdrawal for any reason at post-intervention Adverse events at post-intervention	Setting: Outpatients in Japan. Funding: Funded by Teijin Pharma Limited.

Study	Intervention and comparison	Population	Outcomes	Comments
	Level of supervision: Unsupervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=42) 40 minutes of self training followed by 20 minutes of therapist-led occupational therapy, 3 days a week for 10 weeks. **Concomitant therapy:** No additional information.			
Takahashi 2016[95]	**Robot-assisted arm training** (n=30) 40 minutes of standard therapy plus robot therapy with ReoGo for 40 additional minutes, 7 times a week for 6 weeks. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=30) 40 minutes of standard therapy plus therapist-directed self-training for 40 additional minutes, 7 times a week for 6 weeks.	**People after a first or recurrent stroke** Mean age: Not available* N = 60 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Not available*			
Taravati 2021[97]	**Robot-assisted arm training** (n=22) Hand-arm robotic assisted therapy for 30-45 min, 5 days a week for 4 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=23) Conventional physiotherapy was provided for 5 days a week and for 4 weeks. **Concomitant therapy:** The control group received only conventional therapy for 5 days a week and 4 weeks, while the study groups received the same amount of conventional therapy in addition to rehabilitation with the robotic rehabilitation.	**People after a first or recurrent stroke** Mean age (SD): 53.4 (14.8) years N = 45 Mean time after stroke (SD): 11.8 (8.3) months Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Spasticity at post-intervention Stroke specific quality of life at post-intervention Withdrawal for any reason at post-intervention	Setting: Rehabilitation hospital in Turkey. Sources of funding: Not reported.
Taveggia 2016[98]	**Robot-assisted arm training** (n=27) Robot therapy with the Armeo Spring for 30 minutes per session, 5 times per week for 6 weeks.	**People after a first or recurrent stroke** Mean age: Not available* N = 54 Time after stroke: Mixed (0.5-12	Activities of daily living at post-intervention and ≥6 months Arm muscle strength at post-intervention and ≥6 months	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Region of upper limb trained: Not stated/unclear Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Passive **Any other intervention** (n=27) Physical rehabilitation therapy according to the Bobath concept for 30 minutes per session, 5 times a week for 6 weeks. **Concomitant therapy:** Not available*	months post-stroke) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Spasticity at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≥6 months Adverse events at post-intervention	
Timmermans 2014[99] Subsidiary paper: Lemmens 2014[59]	**Robot-assisted arm training** (n=11) With end-effector robot HapticMaster 4 times/ week, twice a day for 30 minutes (separated by 0.5 hour to 1 hour of rest). Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Mixed **Any other intervention** (n=11) Arm-hand training programme 4 times/ week, twice a day for 30 minutes (separated by 0.5 hour to 1 hour of rest).	**People after a first or recurrent stroke** Mean age: Not available* N = 22 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Person/ participant generic health-related quality of life at post-intervention and ≥6 months Arm function at post-intervention and ≥6 months Withdrawal for any reason at post-intervention and ≤6 months Adverse events at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Concomitant therapy: Not available*			
Tomic 2017[100]	**Robot-assisted arm training** (n=13) Additional robot therapy with the ArmAssist (AA) for 30 minutes administered over 15 sessions each lasting 30 minutes, scheduled 5 days per week for 3 weeks Region of upper limb trained: Proximal limb Level of supervision: Not stated/unclear Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=13) Additional occupational therapy for 30 minutes that was matched in its structure and amount to the AA training as close as possible and administered over 15 sessions each lasting 30 minutes, scheduled 5 days per week for 3 weeks **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: not available* N = 26 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Valles 2016[101]	**Robot-assisted arm training** (n = 13)	**People after a first or recurrent stroke** Mean age: Not available*	Arm function at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this

Study	Intervention and comparison	Population	Outcomes	Comments
	24, 2 hour therapy sessions over a 6-8 week period. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=14) Standard rehabilitation therapy- 24 2-hour therapy sessions over a 6-8 week period. **Concomitant therapy:** Not available*	N = 27 Mean time after stroke: Not stated/unclear (inclusion criteria says a minimum of 6 months post stroke) Ethnicity: Not stated/unclear Severity: Not stated/unclear		review. For further details see Mehrholz 2018[78].
Vanoglio 2017[102]	**Robot-assisted arm training** (n=15) Robot therapy with the Gloreha Professional consisted of a total of 30 sessions, lasting 40 minutes per day, for 5 days per week. Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=15) Passive arm therapy for 30 sessions, lasting 40	**People after a first or recurrent stroke** Mean age: not available* N = 30 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	minutes per day, for 5 days per week **Concomitant therapy:** Not available*			
Villafane 2018[103]	**Robot-assisted arm training** (n=16) Robot therapy with the hand Gloreha for 30 minutes for 3 days per week Region of upper limb trained: Distal limb Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=16) Physical and occupational arm therapy for 30 minutes 3 days per week **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 32 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention Withdrawal for any reason at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Volpe 2000[104] Subsidiary paper: Fasoli 2004[30]	**Robot-assisted arm training** (n=30) The treatment group used the MIT-Manus device for arm training for 1 hour per day, 5 days a week (for at least 25 sessions) Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic	**People after a first or recurrent stroke** Mean age: Not available* N = 56 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	device: Active-assisted **Any other intervention** (n=26) Placebo. The control group had similar initial exposure to the robot with the exception that half the tasks were performed with the unimpaired arm, and when the participant could not perform the task with the affected limb, the unimpaired limb was used to complete the task or the technician assisted the movement. The robot never actively moved the limbs of participants in the control group. Participants were exposed to the robot 1 hour per week. **Concomitant therapy:** Not available*			
Volpe 2008[105]	**Robot-assisted arm training** (n=11) Robotic training with the InMotion2 robot (the commercial version of MIT-Manus). All participants had an identical number of treatment sessions, and the sessions were of the same duration (1 hour per session, 3 times a week for 6 weeks). Region of upper limb trained: Mixed	**People after a first or recurrent stroke** Mean age: not available* N = 21 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Spasticity at post-intervention Stroke-specific Patient Reported Outcome Measures at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	Level of supervision: Supervised Type of movement delivered by robotic device: Passive **Any other intervention** (n=10) Conventional therapy. Intensive movement protocol with a trained physiotherapist. All participants had an identical number of treatment sessions, and the sessions were of the same duration (1 hour per session, 3 times a week for 6 weeks). **Concomitant therapy:** Not available*			
Wolf 2015[106] Subsidiary paper: Linder 2013[63]	**Robot-assisted arm training** (n=51) Robot therapy with the Hand Mentor Pro (Kinetic Muscles Incs) for 60 minutes over a 8 (to 12) weeks period. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=48) Conventional therapy. Home exercises for the arm therapy for 60	**People after a first or recurrent stroke** Mean age: not available* N = 99 Time after stroke: Subacute (7 days - 6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Withdrawal at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	minutes over an 8 (to 12) week period **Concomitant therapy:** Not available*			
Wu 2012[109] Subsidiary papers: Wu[107] Wu 2012[108]	**Robot-assisted arm training** (n=14) Robot-assisted (Bi-Manu-Track) arm trainer (RAT Group). Each group received treatment for 90 to 105 minutes per session, 5 sessions on weekdays, for 4 weeks. Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=28) A combination of two arms. 1) therapist-mediated bilateral arm training and 2)conventional therapy. Each group received treatment for 90 to 105 minutes per session, 5 sessions on weekdays, for 4 weeks. **Concomitant therapy:** Not available*	**People after a first or recurrent stroke** Mean age: Not available* N = 42 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Arm function at post-intervention Stroke-specific Patient Reported Outcome Measures at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].
Xu 2020[110]	**Robot-assisted arm training** (n=22) Robot training was provided in addition 20 min/time,	**People after a first or recurrent stroke** Mean age (SD): 61.4 (10.4) years N = 55	Activities of daily living at post-intervention Arm function at post-intervention	Setting: Rehabilitation hospital in China. Sources of funding: The study was supported by the

Study	Intervention and comparison	Population	Outcomes	Comments
	once/day and five days/week. Region of upper limb trained: Proximal limb Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=23) Traditional occupational therapy. Control group was trained with traditional exercises, 40 min, once/day, and five days/week. **Concomitant therapy:** The patients in both groups received regular neurological medical and physical therapy with equal treatment volume. A 6 weeks rehabilitation programme was designed for all the patients.	Time after stroke (SD): 49.1 (21.8) days Ethnicity: Not stated/unclear Severity: Not stated/unclear	Withdrawal for any reason at post-intervention	Beijing Municipal Administration of hospitals youth programme (No. QML2019002).
Yoo 2013[111]	**Robot-assisted arm training** (n=11) 3-dimensional robot-assisted therapy (RAT) and conventional rehabilitation therapy (CT) for a total of 90 minutes (RAT: 30 minutes, CT: 60 minutes) a day with 10 minutes rest halfway through the session, received	**People after a first or recurrent stroke** Mean age: Not available* N = 22 Time after stroke: Chronic (≥6 months) Ethnicity: Not stated/unclear Severity: Not stated/unclear	Activities of daily living at post-intervention Arm function at post-intervention Arm muscle strength at post-intervention	*This study was included in the original Cochrane review that was updated in this review. For further details see Mehrholz 2018[78].

Study	Intervention and comparison	Population	Outcomes	Comments
	training 3 days a week for 6 weeks Region of upper limb trained: Not stated/unclear Level of supervision: Supervised Type of movement delivered by robotic device: Mixed **Any other intervention** (n=11) The control group received only CT for 60 minutes a day on the same days as the first group **Concomitant therapy:** Not available*			
Zengin-Metli 2018[112]	**Robot-assisted arm training** (n=20) Robot therapy with Armeo Spring HocomAG Inc.for 3 weeks Region of upper limb trained: Mixed Level of supervision: Supervised Type of movement delivered by robotic device: Active-assisted **Any other intervention** (n=15) Conventional program consisted of neurophysiological exercises with Brunnstrom approach, range of motion exercises	**People after a first or recurrent stroke** Mean age (SD): 61.0 (6.9) years N = 35 Mean time after stroke (SD): 11.0 (5.1) weeks Ethnicity: Not stated/unclear Severity: Not stated/unclear	Person/participant generic health related quality of life at post-intervention Activities of daily living Arm function at post-intervention Arm muscle strength at post-intervention	Setting: Stroke rehabilitation centre in Turkey. Sources of funding: Not reported.

Study	Intervention and comparison	Population	Outcomes	Comments
	and postural education for 3 weeks. **Concomitant therapy:** Conventional program consisted of neurophysiological exercises with Brunnstrom approach, range of motion exercises and postural education.			

See Appendix D for full evidence tables.

1.1.6 Summary of the effectiveness evidence

Table 3: Clinical evidence summary: Robot-assisted arm training compared to any other intervention

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
Person/participant health related quality of life (SF-36 PCS, 0-100, higher values are better, change score) at end of intervention	215 (2 RCTs) follow-up: mean 5 weeks	⊕◯◯◯ Very low[a,b]	-	The mean person/participant health related quality of life at end of intervention was 1.37	MD **0.73 higher** (0.81 lower to 2.27 higher)	MID = 2 (SF-36 established MID)
Person/participant health related quality of life (SF-36 MCS, 0-100, higher values are better, change score) at end of intervention	215 (2 RCTs) follow-up: mean 5 weeks	⊕◯◯◯ Very low[a,b]	-	The mean person/participant health related quality of life at end of intervention was 3.84	MD **1.14 lower** (3.5 lower to 1.22 higher)	MID = 3 (SF-36 established MID)
Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final	716 (2 RCTs) follow-up: mean 4 weeks	⊕◯◯◯ Very low[b,c]	-	The mean person/participant health related quality of life at end of	MD **0.01 higher** (0.02 lower to 0.03 higher)	MID = 0.03 (EQ-5D established MID)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
values and change scores) at end of intervention				intervention was 0.23		
Person/participant health related quality of life (EQ5D, 0-100, higher values are better, change score) at ≥6 months	194 (1 RCT) follow-up: 12 months	⊕◯◯◯ Very low[b,d]	-	The mean person/participant health related quality of life at ≥6 months was 19.08	MD **4.67 lower** (10.58 lower to 1.24 higher)	MID = 9.9 (0.5 x median baseline SD)
Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final values) at ≥6 months	625 (1 RCT) follow-up: 6 months	⊕⊕◯◯ Low[b,e]	-	The mean person/participant health related quality of life at ≥6 months was 0.5	MD **0.04 lower** (0.09 lower to 0.01 higher)	MID = 0.03 (EQ-5D established MID)
Activities of daily living (Barthel index, functional independence measure, stroke impact scale, MAL, Frenchay arm test, ABILHAND [different scale ranges], higher values are better, change scores) at end of intervention	1318 (25 RCTs) follow-up: mean 5 weeks	⊕◯◯◯ Very low[a,b,f]	-	-	SMD **0.41 SD higher** (0.16 higher to 0.67 higher)	MID = 0.5 SD (SMD)
Activities of daily living (Barthel index, functional independence measure, Motor activity log [different scale ranges], higher values are better, final values) at end of intervention	988 (11 RCTs) follow-up: mean 5 weeks	⊕⊕⊕⊕ High	-	-	SMD **0.14 SD higher** (0.01 higher to 0.27 higher)	MID = 0.5 SD (SMD)
Activities of daily living (Barthel index, functional	469 (9 RCTs) follow-up:	⊕⊕◯◯ Low[b,f]	-	-	SMD **0.28 SD higher**	MID = 0.5 SD (SMD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
independence measure, motor activity log [different scale ranges], higher values are better, change scores) at ≥6 months	mean 6 months				(0.09 higher to 0.46 higher)	
Activities of daily living (Barthel index, Functional Independence Measure [different scale ranges], higher values are better, final values) at ≥6 months	670 (2 RCTs) follow-up: mean 4 months	⊕⊕◯◯ Low[f]	-	-	SMD **0.02 SD higher** (0.14 lower to 0.17 higher)	MID = 0.5 SD (SMD)
Arm function (FMA UE, Quick DASH, manual function test [different scale ranges], higher values are better, change scores) at end of intervention	2167 (48 RCTs) follow-up: mean 5 weeks	⊕⊕◯◯ Low[f,g]	-	-	SMD **0.34 SD higher** (0.26 higher to 0.43 higher)	MID = 0.5 SD (SMD)
Arm function (FMA UE, Chedoke Arm and Hand Activity [different scale ranges], higher values are better, final values) at end of intervention	1496 (24 RCTs) follow-up: mean 6 weeks	⊕⊕◯◯ Low[b,f]	-	-	SMD **0.2 SD higher** (0.09 higher to 0.31 higher)	MID = 0.5 SD (SMD)
Arm function (FMA UE, 0-66, higher values are better, change scores) at ≥6 months	517 (11 RCTs) follow-up: mean 6 months	⊕⊕⊕◯ Moderate[h]	-	The mean arm function at ≥6 months was 9.01	MD **1.08 higher** (0.09 higher to 2.07 higher)	MID = 6.6 (Fugl-Meyer upper extremity = Difference by 10% of the total scale)
Arm function (FMA UE, Korean DASH	930 (9 RCTs) follow-up:	⊕◯◯◯ Very low[b,f,g]	-	-	SMD **0.61 SD higher**	MID = 0.5 SD (SMD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
[different scale ranges], higher values are better, final values) at ≥6 months	mean 4 months				(0.18 higher to 1.03 higher)	
Arm muscle strength (Motricity index, MRC, manual muscle test, MRC total motor power [different scale ranges], higher values are better, change scores) at end of intervention	1019 (21 RCTs) follow-up: mean 5 weeks	⨁◯◯◯ Very low[a,b,f]	-	-	SMD **0.45 SD higher** (0.17 higher to 0.72 higher)	MID = 0.5 SD (SMD)
Arm muscle strength (Motricity index, MRC [different scale ranges], higher values are better, final values) at end of intervention	107 (3 RCTs) follow-up: mean 4 weeks	⨁◯◯◯ Very low[a,b,f]	-	-	SMD **0.89 SD higher** (0.19 higher to 1.6 higher)	MID = 0.5 SD (SMD)
Arm muscle strength (grip strength [kg], higher values are better, change scores and final values) at end of intervention	123 (5 RCTs) follow-up: mean 5 weeks	⨁⨁⨁◯ Moderate[b]	-	The mean arm muscle strength at end of intervention was 3.48	MD **0.92 higher** (0.39 lower to 2.22 higher)	MID = 1.83 (0.5 x median baseline SD)
Arm muscle strength (grip strength [Newton meter], higher values are better, change score and final value) at end of intervention	114 (2 RCTs) follow-up: mean 6 weeks	⨁⨁⨁⨁ High	-	The mean arm muscle strength at end of intervention was 6.8	MD **0.64 lower** (4.18 lower to 2.91 higher)	MID = 4.3 (0.5 x median baseline SD)
Arm muscle strength (MRC total, MRC total motor power [different scale ranges], higher values are better,	164 (4 RCTs) follow-up: mean 5 months	⨁◯◯◯ Very low[f,i,j]	-	-	SMD **0.48 SD higher** (0.57 lower to 1.53 higher)	MID = 0.5 SD (SMD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
change scores) at ≥6 months						
Arm muscle strength (MRC total, MI [different scale ranges], higher values are better, final value) at ≥6 months	84 (2 RCTs) follow-up: mean 2 months	⊕◯◯◯ Very low[i,k]	-	-	SMD **1.05 SD higher** (0.59 higher to 1.51 higher)	MID = 0.5 SD (SMD)
Arm muscle strength (grip strength [kg], higher values are better, change score and final value) at ≥6 months	71 (2 RCTs) follow-up: mean 6 months	⊕⊕⊕◯ Moderate[b]	-	The mean arm muscle strength at ≥6 months was 5.17	MD **1.06 higher** (1.02 lower to 3.14 higher)	MID = 1.83 (0.5 x median baseline SD)
Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at end of intervention	761 (16 RCTs) follow-up: mean 5 weeks	⊕⊕◯◯ Low[f,l]	-	-	SMD **0.23 SD lower** (0.46 lower to 0.01 lower)	MID = 0.5 SD (SMD)
Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at end of intervention	356 (10 RCTs) follow-up: mean 5 weeks	⊕⊕◯◯ Low[k]	-	-	SMD **0.21 SD lower** (0.42 lower to 0)	MID = 0.5 SD (SMD)
Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at ≥6 months	247 (7 RCTs) follow-up: mean 5 months	⊕⊕◯◯ Low[j,l]	-	-	SMD **0.09 SD lower** (0.34 lower to 0.17 higher)	MID = 0.5 SD (SMD)
Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at ≥6 months	153 (4 RCTs) follow-up: mean 3 months	⊕◯◯◯ Very low[b,i,k]	-	-	SMD **0.2 SD lower** (0.52 lower to 0.12 higher)	MID = 0.5 SD (SMD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, final values and change scores) at end of intervention	284 (5 RCTs) follow-up: mean 7 weeks	⨁⨁◯◯ Low[b,l]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 37.40	MD **5.31 higher** (2.6 higher to 8.02 higher)	MID = 6.12 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain [different scale ranges], higher values are better, change scores) at end of intervention	382 (5 RCTs) follow-up: mean 3 weeks	⨁◯◯◯ Very low[b,f,g]	-	-	SMD **0.8 SD higher** (0.31 lower to 1.91 higher)	MID = 0.5 SD (SMD)
Stroke-specific Patient-Reported Outcome Measures (SS-QOL, 49-245, higher values are better, final value) at end of intervention	37 (1 RCT) follow-up: 4 weeks	⨁◯◯◯ Very low[b,m]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 140.8	MD **2.21 lower** (23.36 lower to 18.94 higher)	MID = 14.1 (0.5 x median baseline SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - strength domain, 0-100, higher values are better, change score) at end of intervention	117 (1 RCT) follow-up: 10 weeks	⨁⨁⨁⨁ High	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 4.43	MD **3.45 higher** (2.58 higher to 4.32 higher)	MID = 1.03 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact	117 (1 RCT) follow-up: 10 weeks	⨁⨁⨁◯ Moderate[b]	-	The mean stroke-specific Patient-Reported Outcome Measures at end	MD **0.19 higher** (0.52 lower to	MID = 0.84 (0.5 x median control group SD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
Scale - memory domain, 0-100, higher values are better, change score) at end of intervention				of intervention was 1.4	0.9 higher)	
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - emotion domain, 0-100, higher values are better, change score) at end of intervention	117 (1 RCT) follow-up: 10 weeks	⊕⊕⊕◯ Moderate [b]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 0.78	MD **1.24 lower** (1.7 lower to 0.78 lower)	MID = 0.91 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - communication domain, 0-100, higher values are better, change score) at end of intervention	117 (1 RCT) follow-up: 10 weeks	⊕⊕⊕◯ Moderate [b]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 0.9	MD **0.32 lower** (0.94 lower to 0.3 higher)	MID = 0.8 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, 0-100, higher values are better, change scores and final value) at end of intervention	742 (3 RCTs) follow-up: mean 8 weeks	⊕◯◯◯ Very low [f,n]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 20.8	MD **0.12 higher** (4.56 lower to 4.8 higher)	MID = 7.44 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, 0-100, higher values are better, change score and final	725 (2 RCTs) follow-up: 12 weeks	⊕⊕⊕⊕ High	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 32.2	MD **0.44 higher** (3.91 lower to 4.79 higher)	MID = 6.5 (0.5 x median control group SD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
value) at end of intervention						
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social participation domain, 0-100, higher values are better, change score and final value) at end of intervention	721 (2 RCT) follow-up: 12 weeks	⊕⊕⊕◯ Moderate [b]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 25.5	MD **2.81 higher** (5.98 lower to 11.6 higher)	MID = 6.7 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - stroke recovery domain, 0-100, higher values are better, change score) at end of intervention	117 (1 RCT) follow-up: 10 weeks	⊕⊕⊕◯ Moderate [b]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 7.43	MD **1.11 higher** (0.21 higher to 2.01 higher)	MID = 1.18 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - physical domain, 0-100, higher values are better, change score) at end of intervention	117 (1 RCT) follow-up: 10 weeks	⊕⊕⊕⊕ High	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 2.28	MD **3.52 higher** (2.99 higher to 4.05 higher)	MID = 0.68 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final value) at end of intervention	608 (1 RCT) follow-up: mean 12 weeks	⊕⊕⊕◯ Moderate [o]	-	The mean stroke-specific Patient-Reported Outcome Measures at end of intervention was 18.1	MD **2.6 lower** (6.75 lower to 1.55 higher)	MID = 13.0 (0.5 x median control group SD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, change score and final value) at ≥6 months	90 (2 RCTs) follow-up: mean 5 months	⊕⊕◯◯ Low[k,p]	-	The mean stroke-specific Patient-Reported Outcome Measures at ≥6 months was 25.1	MD **4.36 higher** (1.64 lower to 10.36 higher)	MID = 12.0 (0.5 x median baseline SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final values and change scores) at ≥6 months	819 (3 RCTs) follow-up: mean 7 months	⊕⊕⊕◯ Moderate[n]	-	The mean stroke-specific Patient-Reported Outcome Measures at ≥6 months was 23.22	MD **0.27 lower** (3.98 lower to 3.45 higher)	MID = 8.3 (0.5 x median baseline SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, higher values are better, change score and final value) at ≥6 months	625 (2 RCTs) follow-up: mean 4 months	⊕⊕⊕◯ Moderate[n]	-	The mean stroke-specific Patient-Reported Outcome Measures at ≥6 months was 29.87	MD **2.21 lower** (5.71 lower to 1.28 higher)	MID = 8.2 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, higher values are better, final value) at ≥6 months	608 (1 RCT) follow-up: 6 months	⊕⊕⊕◯ Moderate[o]	-	The mean stroke-specific Patient-Reported Outcome Measures at ≥6 months was 63.4	MD **1.7 lower** (5.77 lower to 2.37 higher)	MID = 11.9 (0.5 x median control group SD)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social	604 (1 RCT) follow-up: 6 months	⊕⊕⊕◯ Moderate[o]	-	The mean stroke-specific Patient-Reported Outcome Measures at ≥6 months was 50.0	MD **3 lower** (7.23 lower to 1.23 higher)	MID = 12.1 (0.5 x median control group SD)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
participation domain, higher values are better, final value) at ≥6 months						
Withdrawal for any reason at end of intervention	3954 (72 RCTs) follow-up: mean 6 weeks	⨁◯◯◯ Very low[q,r]	RD 0.00 (-0.02 to 0.02)	86 per 1,000	**0 fewer per 1,000** (20 fewer to 20 more)[s]	Precision calculated through Optimal Information Size (OIS) due to zero events in some studies. OIS determined power for the sample size = 0.04 (0.8-0.9 = serious, <0.8 = very serious).
Withdrawal for any reason at ≥6 months	1672 (21 RCTs) follow-up: mean 6 months	⨁◯◯◯ Very low[q,r]	RD -0.02 (-0.04 to 0.01)	84 per 1,000	**20 more per 1,000** (40 fewer to 10 more)[s]	Precision calculated through Optimal Information Size (OIS) due to zero events in some studies. OIS determined power for the sample size = 0.13 (0.8-0.9 = serious, <0.8 = very serious).
Adverse events (cardiovascular	770 (1 RCT)	⨁⨁◯◯ Low[b]	RR 4.99	4 per 1,000	**16 more per**	MID (precision)

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
events) at end of intervention	follow-up: 3 months		(0.97 to 25.55)		**1,000** (0 fewer to 96 more)	= RR 0.80 – 1.25.
Adverse events (cardiovascular events) at ≥6 months	770 (1 RCT) follow-up: 6 months	⊕⊕◯◯ Low[b]	RR 2.00 (0.28 to 14.09)	4 per 1,000	**4 more per 1,000** (3 fewer to 51 more)	MID (precision) = RR 0.80 – 1.25.
Adverse events (injuries and pain) at end of intervention	555 (5 RCTs) follow-up: mean 7 weeks	⊕◯◯◯ Very low[q,r]	RD 0.03 (-0.07 to 0.13)	311 per 1,000	**30 more per 1,000** (70 fewer to 130 more)[s]	Precision calculated through Optimal Information Size (OIS) due to zero events in some studies. OIS determined power for the sample size = 0.12 (0.8-0.9 = serious, <0.8 = very serious).
Adverse events (injuries and pain) at ≥6 months	299 (3 RCTs) follow-up: mean 6 months	⊕⊕⊕⊕ High	RD 0.00 (-0.02 to 0.02)	0 per 1,000	**0 fewer per 1,000** (20 fewer to 20 more)[s]	Sample size used to determine precision: 75-150 = serious imprecision, <75 = very serious imprecision. MID (clinical importance) = 50 per 1,000.

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
Adverse events (other reported adverse events) at end of intervention	1736 (19 RCTs) follow-up: mean 6 weeks	⊕◯◯◯ Very low[q,r]	RD 0.01 (-0.01 to 0.04)	87 per 1,000	**10 more per 1,000** (10 fewer to 40 more)[s]	Precision calculated through Optimal Information Size (OIS) due to zero events in some studies. OIS determined power for the sample size = 0.25 (0.8-0.9 = serious, <0.8 = very serious).
Adverse events (other reported adverse events) at ≥6 months	1274 (10 RCTs) follow-up: mean 5 months	⊕◯◯◯ Very low[q,r]	RD 0.00 (-0.03 to 0.04)	113 per 1,000	**0 fewer per 1,000** (30 fewer to 40 more)[s]	Precision calculated through Optimal Information Size (OIS) due to zero events in some studies. OIS determined power for the sample size = 0.52 (0.8-0.9 = serious, <0.8 = very serious).

a. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias arising from the randomisation process, bias due to deviation from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome)

b. Downgraded by 1 increment if the confidence interval crossed one MID or by 2 increments if the confidence interval crossed both MIDs

Outcomes	№ of participants (studies) Follow-up	Certainty of the evidence (GRADE)	Relative effect (95% CI)	Anticipated absolute effects		Comments
				Risk with any other intervention	Risk difference with robot-assisted arm training	
[c] Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias in the randomisation process, bias due to missing outcome data and bias in measurement of the reported result) [d] Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias in measurement of the outcome and bias in selection of the reported result) [e] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to bias in measurement of the outcome) [f] Downgraded by 1 or 2 increments because heterogeneity, unexplained by subgroup analysis [g] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data, bias in measurement of the outcome and bias in selection of the reported result) [h] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention and bias due to missing outcome data) [i] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome) [j] Downgraded by 1 increments due to outcome indirectness (as the majority of evidence was reported at a follow up of less than 6 months) [k] Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias arising from the randomisation process, bias due to deviation from the intended intervention, bias due to missing outcome data, bias in measurement of the outcome and bias in selection of the reported result) [l] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome) [m] Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias due to deviation from the intended intervention and bias due to missing outcome data) [n] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process and bias in measurement of the outcome) [o] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to bias in measurement of the outcome) [p] Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention and bias due to missing outcome data) [q] Downgraded for heterogeneity due to conflicting number of events in different studies (zero events in one or more studies) [r] Downgraded by 1 to 2 increments for imprecision due to zero events and small sample size [s] Absolute effect calculated by risk difference due to zero events in at least one arm of one study						

See Appendix F for full GRADE tables.

1.1.7 Economic evidence

1.1.7.1 Included studies

Two health economic studies with the relevant comparison were included in this review.[32,50] These are summarised in the health economic evidence profile below (Table 4) and the health economic evidence tables in Appendix H. Note that one study,[32] as well as the RCT[88] that formed the basis of the analysis are also included as part of the evidence review for this guideline that assessed the clinical and cost-effectiveness of more intensive rehabilitation.

1.1.7.2 Excluded studies

No relevant health economic studies were excluded due to assessment of limited applicability or methodological limitations.

See also the health economic study selection flow chart in Appendix G.

1.1.8 Summary of included economic evidence

Table 4: Health economic evidence profile: Robot-assisted arm training versus usual care

Study	Applicability	Limitations	Other comments	Incremental cost	Incremental effects	Cost effectiveness	Uncertainty
Fernandez-Garcia 2021[32] (UK)	Directly applicable	Minor limitations[(a)]	• Within-trial analysis of RATULS RCT[88] (n=768) • Cost-utility analysis (QALYs) • Population: adults with moderate or severe upper limb functional limitation as a result of first-ever stroke that had occurred between 1 week and 5 years before randomisation • Comparators: 1. Usual care (45 minutes with a physiotherapist or occupational therapist, 5 days a week) 2. More intensive – robot-assisted training (45 minutes per day, 3 times per week) plus usual care 3. More intensive – enhanced upper limb therapy (EULT) (45 minutes with a physiotherapist, 3 times per week) plus usual care. • Time horizon: 6 months	2-1: £1601[(b)] 3-1: £741[(b)] 3-2: Saves -£936[(b)]	2-1: 0.00 QALYs 3-1: 0.01 QALYs 3-2: 0.02 QALYs	2-1: More intensive rehabilitation (robot arm training) was dominated by usual care. 3-1 (More intensive (EULT) vs usual care): £74,100 per QALY gained 3-2: EULT dominated Robot (lower costs and higher QALYs)	Probability cost effective (£20K threshold): • usual care 81% • more intensive (robot) 0% • more intensive (EULT) 19% Sensitivity analyses around missing data and robot costs did not change conclusions. Extrapolation of data to 12-month time horizon made more intensive rehabilitation (EULT) cost effective compared to usual care (£6,095; probability cost effective 55%). More intensive (robot) remained dominated by usual care.

Study	Applicability	Limitations	Other comments	Incremental cost	Incremental effects	Cost effectiveness	Uncertainty
Remy-Neris 2021[50]	Partially applicable[(c)]	Potentially serious limitations[(d)]	• Within-trial analysis of an RCT (n=215) included in the clinical review (same paper) with no modelled extrapolation. • Cost-utility analysis (QALYs) • Population: Adults, 3 weeks to 3 months post-stroke, with an FMA score of 10 to 40 points. • Comparators: 1) Control group (n=108) was provided with usual rehabilitation for 1 hour, 5 days per week plus an additional daily hour of self-rehabilitation consisting of basic stretching and active exercises for 4 weeks. 2) Exo group (n=107) was provided with usual rehabilitation for 1 hour, 5 days per week plus an additional daily hour of self-rehabilitation consisting of gravity-supported, games-based training using an exoskeleton (Armeo®Spring) for 4 weeks • Follow-up: 12 months	2−1: Saves £99[(e)]	2−1[(f)]: 0.01 QALYs	Results suggested that the Exo group intervention dominates usual care (lower costs and higher QALYs), however total costs and QALY gains were not statistically significant between groups.	Probability of cost effective (£20K/£30K threshold): NR Results were robust to probabilistic sensitivity analysis, where uncertainty on the ICER was described using 1000 bootstrap replications on the cost-effectiveness plane.

Abbreviations: 95% CI= 95% confidence interval; EQ-5D-3L= EuroQol 5 dimensions 3 levels (scale: 0.0 [death] to 1.0 [full health], negative values mean worse than death); FIM= functional independence measure (scale 0-18, higher values are better); FMA UE= Fugl-Meyer Assessment Upper Extremity (scale 0-66, higher scores are better); ICER= incremental cost-effectiveness ratio; NA= not applicable; NR= not reported; QALYs= quality-adjusted life years; RCT= randomised controlled trial; SIS hand function= stroke Impact Scale - hand function domain (scale 0-100, higher values are better).

(a) Within-trial analysis based on RATULS RCT and so only reflects this study and not the wider evidence base identified in the clinical review.

(b) 2018 UK pounds. Cost components incorporated: intervention costs, follow-up costs, primary care, therapy and community-based, services, secondary care, residential and nursing home care, social services, medication costs. Unit costs were taken from 2017/18 NHS reference costs and 2017 PSSRU unit costs (which were inflated to 2018 prices using the Bank of England inflator[7])

(c) French healthcare system may not reflect current UK NHS context. EQ-5D-3L French tariff was used to estimate QALYs but NICE reference case specifies that the UK tariff is preferred.

(d) Within-trial analysis based on a single-blinded RCT, therefore results only reflect this study and not the wider evidence base identified in the clinical review. References for unit costs were not reported which limits interpretation of results for UK context. Probability that intervention was cost-effective at £20K threshold was not reported.

(e) 2018 euros (€) converted to UK pounds purchasing power parities.[81] References for unit costs were not reported but 2018 was assumed based on the study completion date. No significant between-group differences were reported for total costs (p=0.99). Cost components incorporated: Armeo®Spring exoskeleton (device cost, 5-year linear depreciation, maintenance, and physical therapist for patient training). Resource use estimates included inpatient rehabilitation days, outpatient physiotherapy, GP and specialist consultations and transportation costs.

(f) Mean difference taken from Figure 4 of guideline clinical review. There were no significant between-group differences in changes for any of the reported outcomes at any time point (p>0.05).

1.1.9 Economic model

This area was not prioritised for new cost-effectiveness analysis.

1.1.10 Unit costs

Relevant unit costs are provided below to aid consideration of cost effectiveness.

The main additional resource use of robot-assisted arm training is the cost of the robotic device. The studies included in the clinical review used different robots. The RATULS RCT (Rodgers 2019[88]), conducted as part of the Health Technology Assessment (HTA) programme, provided UK costs associated with the MIT-Manus robotic gym. This included the initial capital investment and maintenance fees. Costs associated with a trial centre's estate and facilities were included in the salary costs of the staff delivering the therapy, and so are not incorporated in the robotic device costing below (staff costs were incorporated in the cost effectiveness analysis above however). No additional storage facilities were identified as the robotic gyms were installed in the therapy room. The allocation of these capital costs was conducted following the 'equivalent annual cost' methodology by Drummond 2005[29]. This method allowed for the initial capital cost to be converted into an annual sum that equals the resources invested plus their opportunity cost.

The equivalent annual cost of each robot session was calculated under the following assumptions:

- Robot usage: 35 average number of sessions per week (seven sessions held on an 8-hour day). Weeks per year that the MIT-Manus robotic gym system is in use: 52 weeks.
- Useful lifespan of the MIT-Manus robotic gym system is 5 years.
- Training costs are not included as they are not considered to drive any differences in costs between randomisation groups.
- The capital cost of the robotic gym was spread over its lifespan (5 years).
- A discount factor of 3.5% was applied to account for the individual's time preference for costs to be incurred later rather than sooner. This follows guidance for best practice.

Tables 5 and 6 illustrate this method, incorporating the initial purchasing cost of £1,000,000 for the MIT-Manus robotic gym and £15,000 annual fees.

Table 5: Equivalent annual cost or equivalent annuity from Rodgers 2019[88]

Year	Discount factor at 3.5%[(a)]	Equivalent annual cost of £263,084[(b)] (£)
1	0.9662	272,292
2	0.9335	138,487
3	0.9019	93,904
4	0.8714	71,625
5	0.8420	58,268

(a) Discount factor (D^n) = 1(1 + r)^n, where r = discounting rate (e.g. 3.5%)
(b) Equivalent annual cost (A_n) = r/(1 – D_n). Discount factor (D_n) = 1(1 + r)$_n$, where r = discounting rate (e.g. 3.5%).

Table 6: Illustrative cost of the MIT-Manus robotic gym per session from Rodgers 2019[88]

Cost of robot per session	Cost (£)
Capital	
Opportunity cost of the capital (£58,268 × 5)	291,340
Annual cost of robotic gym	58,268
Annual cost of robotic gym per week (assume 52 weeks)	1121
Cost of robot per session – assuming an average of seven sessions per day	32
Maintenance	
Annual maintenance costs	16,234
Maintenance costs per week (52 weeks)	312
Maintenance costs per session (35 sessions in 1 week)	8.92
Total	
Robotic gym cost per session (capital + maintenance)	41

Resource use varied across studies included in the clinical review due to the following factors:

- Variation in the frequency and duration of training time with the robot-assisted device, with sessions ranging from 20 minutes to 60 minutes, not including time spent receiving conventional rehabilitation therapy. In some instances, robot-assisted arm training added more intervention time, and, in these cases, there would be additional staff time costs. Sessions mostly occurred 3-5 days per week. In the included clinical studies, the interventions were delivered for between 2 weeks and 9 weeks and had follow-up periods from 3 weeks up to 8 months.
- A small number of studies included other interventions being given with robot-assisted training (such as neuromuscular, transcranial and functional electrical stimulation) which would also be an additional cost.
- Training was primarily supervised by a member of the rehabilitation team, such as occupational therapists and physiotherapists. However, one study from the clinical review (Budhota 2021[11]) reported that the training was minimally supervised by occupational therapists as well as bioengineers. Rodgers 2019[88] reported that therapists and therapy assistants delivered interventions.
- The level of supervision differed across studies as well. Most studies were reported to have participants supervised by therapists, however, Hesse 2005[40] reported that while patients were left unsupervised during the training, a therapist remained 'within shouting distance' in case of problems and Housman 2009[42] reported mixed supervision, where the first three sessions were supervised before offering intermittent supervision for the remaining sessions. Remy-Neris 2021[50] assessed a similar approach, where a therapist was present during the first 4 sessions but for the remaining sessions, the therapist set the patient up in the device, adjusted the device parameters, and programmed the exercises, but the participant then trained independently.
- Additional resource use required as part of the intervention, such as staff-training costs.

Table 7: Unit costs of health care professionals who may be involved in delivering robot-assisted arm training interventions

Resource	Cost per working hour (hospital / community) [(a)]	Source
Band 6 PT/OT	£53 / £55	PSRRU 2021{, #4635}
Band 7 PT/OT	£64 / £66	

Resource	Cost per working hour (hospital / community) [a]	Source
Rehabilitation assistant	£33/£32	PSRRU 2021{, #4635}, estimated based on agenda for change band 3 salary[b]

Abbreviations: OT= occupational therapist; PT= physiotherapist; PSSRU= personal social services research unit.
(a) Note: Costs per working hour include salary, salary oncosts, overheads (management and other non-care staff costs including administration and estates staff), capital overheads and qualification costs.
(b) Band 3 PT/OT not in PSSRU 2021 so salary was assumed to equal Band 3 Mean annual basic pay per FTE for administration and estates staff, NHS England (PSSRU2021 p.149).

Economic considerations: trade-off between net clinical effects and costs

1.1.11 Evidence statements

Effectiveness/Qualitative

Economic

- One cost-utility analysis found that robot-assisted arm training plus usual care was dominated (higher costs and lower QALYs) by usual care alone for people following a stroke. This analysis was assessed as directly applicable with potentially serious limitations.
- One cost-utility analysis suggested that for people following stroke, usual rehabilitation plus an additional hour of games-based self-rehabilitation using an exoskeleton incurred lower costs and higher QALYs compared to usual rehabilitation alone, however total costs and QALY gains were not statistically significant between groups. This analysis was assessed as partially applicable with potentially serious limitations.

1.1.12 The committee's discussion and interpretation of the evidence

1.1.12.1. The outcomes that matter most

The committee included the following outcomes: person/participant generic health-related quality of life, carer generic health-related quality of life, activities of daily living, arm function, arm muscle strength, spasticity, stroke-specific Patient-Reported Outcome Measures, withdrawal for any reason and adverse events (including cardiovascular events, injuries and pain and other reported adverse events). All outcomes were considered equally important for decision making and therefore have all been rated as critical.

This review updated a published Cochrane review[78]. Therefore, the outcomes used in this review are the same as those reported in the Cochrane review with the inclusion of four additional outcomes which were agreed by the guideline committee: person/participant and carer generic health-related quality of life, stroke-specific Patient-Reported Outcome Measures and spasticity. Person/participant and carer generic health-related quality of life outcomes were added to this review as they are important outcomes for understanding the holistic impact of the treatment and to further understanding of the economic considerations. Similarly, stroke-specific Patient-Reported Outcome Measures were added as these provide insight into how the interventions affect the persons functional abilities or quality of life. The spasticity outcome was added as the committee deemed it important given the nature of the intervention and as previous research has highlighted increases in spasticity as a potential adverse effect of robot assisted therapy.

The committee chose to investigate these outcomes at post intervention and at more than and equal to 6 months follow up period as they considered that there could be a difference in the short-term and long-term effects of the intervention.

There was a large amount of evidence available for the majority of the outcomes at both follow up time points with the number of studies reporting each outcome ranged from 2 to 66. Evidence was more limited for person/participant health-related quality of life and cardiovascular adverse events, but there was sufficient evidence available for the committee to make a recommendation.

1.1.12.2 The quality of the evidence

Seventy-five randomised controlled trial studies were included in the review including six crossover RCTs (in which only the first phase was analysed as a parallel trial). Evidence was available for robot assisted arm training compared to any other intervention (including usual care, placebo and no treatment) at post-intervention and after 6 months follow up periods. Results from studies that compared robot assisted arm training to any of the above interventions were pooled together in the analysis as this was the method employed by the Cochrane review.

The evidence varied from high to very low quality, with the majority being of very low quality. Outcomes were commonly downgraded for risk of bias, inconsistency, indirectness and imprecision. Risk of bias was rated as a concern in the majority of the studies. This was generally due to bias in the randomisation procedure, bias arising due to deviations from the intended interventions, bias in the measurement of the reported result and bias arising from missing outcome data.

Inconsistency was present in many of the outcomes due to the large number of studies and the heterogeneity in the included evidence which reported different time periods post-stroke, doses of the intervention and sample sizes. Heterogeneity was investigated with sensitivity analyses and the pre-specified subgroup analyses. None of the analyses resolved the heterogeneity so these outcomes were downgraded for inconsistency. In several cases the heterogeneity was deemed to be due to differences in the study sample sizes (specifically Rodgers 2019 had a much larger population than any others in the review). Therefore, to avoid over emphasising the effects of the smaller unblinded studies in the analysis a fixed effects analysis was employed for these outcomes rather than using a random effects model.

Seven outcomes were downgraded due to outcome indirectness arising from a short follow up duration. As detailed in the protocol, any outcome reported after the post intervention follow up (and at the longest available follow up time point) was included in the more than and equal to 6 months follow up category. However, if these outcomes were reported at less than 6 months they were downgraded for indirectness. Imprecision was seen in several outcomes due to small sample sizes and uncertainty around the effect estimate.

The committee concluded that the evidence was of a sufficient quality to make recommendations. The committee noted that studies took place in a wide range of countries worldwide which in some of cases may limit applicability to the NHS. One lay member also voiced their concern that a number of studies have been funded by the manufacturers which may introduce further bias in these studies. However, a large multi-site NIHR funded study ([88]) recently took place in the UK which included a health economic analysis. This study reported many of the outcomes included in this review and was of low risk of bias. Therefore, the committee gave this study greater consideration in their decision making.

1.1.12.3 Benefits and harms

The results showed that when robot assisted arm training was compared to any other intervention an inconsistent effect was seen. There was a clinically important benefit in some outcomes and no clinically important difference in other outcomes in arm function at more

than and equal to 6 months and arm muscle strength at end of intervention and more than and equal to 6 months. An unclear effect where some outcomes showed a clinically important benefit, some no clinically important difference and one a clinically important harm was also seen in stroke-specific Patient-Reported Outcome Measures at end of intervention.

No clinically important difference was seen in person/participant generic health-related quality of life at end of intervention, arm function at end of intervention, spasticity at end of intervention and more than and equal to 6 months, stroke-specific Patient-Reported Outcome Measures at more than and equal to 6 months, withdrawal for any reason at end of intervention and more than and equal to 6 months and adverse events (including cardiovascular events, injuries and pain and other reported adverse events) at end of intervention and more than and equal to 6 months.

An inconsistent effect where some outcomes showed no clinically important difference and some showed a clinically important harm was seen in person/participant generic health-related quality of life at more than and equal to 6 months. The committee acknowledged that where there was evidence that robot arm therapy was worse than any other intervention at improving quality of life, this was based on evidence from the Rodgers 2019[88] study, which was a large RCT in which the 2 comparison groups (an enhanced upper limb therapy intervention and usual care) were combined for the analysis. The committee considered the fact that the enhanced therapy group received regular one on one, face-to-face physiotherapy treatment which seemed to be more intensive than the usual care provided in other studies. Hence, the committee suggested this may explain the benefit for the other interventions arm for this outcome. Furthermore, when the robot assisted arm training arm was compared to the usual care arm alone the results showed a small benefit for robot therapy in the post-intervention follow-up and no difference at more than and equal to 6 months.

The committee acknowledged the benefits reported for several of the arm muscle strength outcomes and concluded that robot assisted arm training may be appropriate for improving muscle strength alone. However, this does not appear to translate to functional gains, improvements in activities of daily living and ultimately in the person's quality of life. These outcomes may be more important to the holistic wellbeing of the person and was considered in their deliberation. However, the committee agreed that improving upper limb strength may reduce pain and improve joint stability. Therefore, they suggested that these devices may be appropriate for strength training in a specific subset of patients who present with a motor deficit and in whom upper limb strengthening is the main goal of treatment. These findings were echoed in the experiences of one lay member who had used a robotic device during his rehabilitation and suggested that although it may have helped improve his strength in the short term it did not seem to have any lasting positive effects on his function.

The committee also discussed the results of the Rodgers 2019[88], study which found greater improvements in the enhanced upper limb therapy group when compared to the robot-assisted arm training group for many outcomes. This enhanced therapy arm included face-to-face functional task training delivered by a physiotherapist which was matched for time with the robot therapy arm. Based on these findings the committee argued that more intensive physiotherapy for the upper limb seems to be more effective than additional therapy delivered by the robot device. This view was supported by the lay members who preferred therapy sessions delivered by physiotherapists rather than 'being left alone with a machine'. One lay member suggested that the personal relationships formed with the physiotherapist are crucial for building trust and increasing motivation to engage in therapy sessions. They also noted that technical issues with the devices along with time spent explaining and setting up the devices wasted valuable therapy time.

On reviewing the evidence, the committee considered the balance of benefits and harms and the large amount of evidence reporting no clinically important difference. Ultimately, they agreed that the evidence did not support a recommendation for the use of robot-assisted arm

training. The committee were satisfied by the amount of evidence available and noted that the evidence encompassed a wide range of robotic devices performing different types of movement at different doses and in subacute/chronic time periods post stroke. Therefore, they did not feel that a research recommendation was necessary.

Despite the lack of evidence in support of robot assisted arm training there was also no evidence reporting a harm of the device. Therefore, the committee agreed that if services already have access to a robot device there is no clinical reason why they should avoid using it in specific circumstances (for example: people after stroke who present with upper limb motor problems in whom the main treatment goal is to improve upper limb strength). However, the overall clinical benefit of a sole improvement in muscle strength was unclear as there was no evidence to suggest that overarching outcomes which may be more important to people after stroke, such as quality of life, would be improved and there would be resource use implications. This time could also be used by a therapist for other therapy that may be able to achieve greater benefits in other areas that may impact quality of life more. Taking into account these factors, and the cost effectiveness evidence, the committee concluded that robot-assisted arm training should not be offered as part of an upper limb rehabilitation program.

1.1.12.4 Cost effectiveness and resource use

Two health economic analyses were identified for this review. The first study included in the review was a within-trial cost-utility analysis of an RCT included in the clinical review, which compared usual rehabilitation (1 hours, 5 days per week for 4 weeks) plus an additional daily hour of self-rehabilitation , consisting of basic stretching and active exercises for the control group versus usual rehabilitation plus an additional daily hour of self-rehabilitation consisting of gravity-supported, games-based training using an exoskeleton (Armeo®Spring). The results suggested that the Exo group intervention dominates usual care (lower costs and higher QALYs), however total costs and QALY gains were not statistically significant between groups. The study conclusions were shown to be robust following a probabilistic sensitivity analysis. The analysis was assessed as partially applicable as the study was set in the French healthcare system which may not reflect the current UK NHS context. In addition, the French population valuation tariff was used to estimate QALYs, but NICE reference case specifies that the UK tariff is preferred. Potentially serious limitations were identified as the study was a within-trial analysis of a single RCT which meant the results only reflect this study and not the wider evidence based identified in the clinical review. References for unit costs were not reported either which further limits the interpretation of the results for a UK context.

The second study was also a within-trial cost-utility analysis of a UK RCT included in the clinical review, where participants were randomised to one of three programmes over a 12-week period: usual care (45 minutes with a physiotherapist or occupational therapist, 5 days a week); robot-assisted training (45 minutes per day, 3 times per week) plus usual care or the EULT programme (45 minutes with a physiotherapist, 3 times per week) plus usual care. The results found that robot-assisted arm training was not cost-effective, as it incurred higher overall costs than both usual care and EULT, primarily due to having higher intervention costs. In addition, robot-assisted training was not associated with higher QALYs than usual care and resulted in lower QALYs than EULT.

There was low uncertainty in this conclusion. Note the conclusions about the EULT intervention are discussed in the intensity of rehabilitation evidence report. The analysis was assessed as directly applicable with minor limitations. Although it is a within-RCT analysis and so only reflects the results of this study, the RCT was a large, recent, NIHR funded, UK-based study that was considered highly applicable by the committee. In addition, while it had a limited follow-up period, sensitivity analyses that extrapolated the trial data to a 12-month time horizon did not change the study conclusions regarding robot arm training.

The committee were also presented with intervention costs from the NIHR study, which incorporated capital and maintenance costs for the robot as well as physiotherapy time to supervise the training. The estimated cost per session of the robot was £41 (assuming the robot is used for an average of 35 session per week for 52 weeks per year with capital costs spread over 5 years). This incorporated an initial purchase cost of £1,000,000 and £15,000 annual fees. Physiotherapy time with robot-assisted training was the same as for EULT and higher than usual care. The committee noted that they were unsure if people would receive supervision from a physiotherapist for the entire duration of robot-training if this was provided in clinical practice. Less staff supervision would suggest lower intervention costs than what is reported in the analysis but given that there wasn't an increase in QALYs with robot-arm training it would still not be cost-effective in this case. It is also unknown if less supervision would affect clinical outcomes. The committee also highlighted that storage and space to use the devices in an NHS setting would likely be an issue. Costs related to this were not captured in the NIHR study as it was possible to install the robot in existing therapy rooms, however the committee did not think this would always be possible.

The committee stated that robot arm training is not commonly used in current practice, however it was noted that a few UK hospitals currently own a robot-training machine. They discussed that even where machines were already available there would be ongoing maintenance costs and use would require staff time for supervision of the intervention (and machines would ultimately need replacing if use continued). In addition, it was noted that if machines were only used in a small subset of patients and so could not be used to full capacity this may increase the cost per use and so overall intervention costs. The committee also highlighted that time was also required for setting-up the machine for each use and to teach the person how to use it. Staff training costs to use the machine may also be incurred. For these reasons the committee agreed that there would be a significant resource impact associated with robot arm training and alongside the limited clinical evidence the committee concluded the robot arm training was not cost-effective for the NHS and made a 'do not offer' recommendation.

1.1.13 Recommendations supported by this evidence review

This evidence review supports recommendation 1.13.18.

1.1.14 References

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Appendices

Appendix A – Review protocols

Review protocol for robot assisted arm training

ID	Field	Content
0.	PROSPERO registration number	CRD42021283317
1.	Review title	In people after stroke, what is the clinical and cost effectiveness of robot-assisted arm training in improving function and reducing disability?
2.	Review question	In people after stroke, what is the clinical and cost effectiveness of robot-assisted arm training in improving function and reducing disability?
3.	Objective	To determine the clinical and cost-effectiveness of robot-assisted arm training in improving function for people after a stroke.
4.	Searches	Mehrholz, J. et al. (2018). Electromechanical and robot-assisted arm training for improving activities of daily living, arm function and arm muscle strength after stroke. Cochrane Database of Systematic Reviews. 9. DOI: 10.1002/14651858.CD006876.pub5. The following databases (from inception) will be searched: • Cochrane Central Register of Controlled Trials (CENTRAL) • Cochrane Database of Systematic Reviews (CDSR) • Embase • MEDLINE • CINAHL • AMED • Epistimonikas Searches will be restricted by: • English language studies • Human studies • Date limitation: From January 2018. Other searches: • Inclusion lists of systematic reviews

		The searches may be re-run 6 weeks before the final committee meeting and further studies retrieved for inclusion if relevant. The full search strategies will be published in the final review. Medline search strategy to be quality assured using the PRESS evidence-based checklist (see methods chapter for full details).
5.	Condition or domain being studied	Adults and young people (16 or older) after a stroke
6.	Population	Inclusion: • Adults (age ≥16 years) who have had a first or recurrent stroke (including people after subarachnoid haemorrhage). Exclusion: • Children (age <16 years) • People who had a transient ischaemic attack
7.	Intervention/Exposure/Test	• Robot-assisted arm training (all types pooled together)
8.	Comparator/Confounding factors	Any other intervention (including usual care and no treatment – all comparators pooled together) Confounding factors (for non-randomised studies only): • Presence of comorbidities • Stroke severity • Time period since stroke

9.	Types of study to be included	• Systematic reviews of RCTs
		• Parallel RCTs
		• Cross over trials (only the first study period will be included)
		• Non-randomised studies (if insufficient RCT evidence is available)
		  ○ Prospective cohort studies
		  ○ Retrospective cohort studies
		  ○ Case-control studies
		
		Published NMAs and IPDs will be considered for inclusion.
		
		Non-randomised studies will only be included if all of the key confounders have been accounted for in a multivariate analysis. In the absence of multivariate analysis, studies that account for key confounders

		with univariate analysis or matched groups will be considered.
10.	Other exclusion criteria	• Non-English language studies. • Non comparative cohort studies • Before and after studies • Conference abstracts will be excluded as it is expected there will be sufficient full text published studies available.
11.	Context	People with a reduction in arm function after a stroke. This may include people in an acute (<7 days), subacute (7 days – 6 months) or chronic (>6 months) time horizon.
12.	Primary outcomes (critical outcomes)	All outcomes are considered equally important for decision making and therefore have all been rated as critical: At the following time periods: • Post-intervention (outcomes reported immediately after the intervention has finished). • ≥6 months (the longest time period will be used for this outcome. If the outcome is less than 6 months, then it will be included but downgraded for indirectness). • Person/participant generic health-related quality of life (continuous outcomes will be prioritised) o EQ-5D o SF-6D o SF-36 o SF-12 o Other utility measures (AQOL, HUI, 15D, QWB) • Carer generic health-related quality of life (continuous outcomes will be prioritised) o EQ-5D o SF-6D o SF-36 o SF-12 o Other utility measures (AQOL, HUI, 15D, QWB) • Activities of daily living (continuous outcomes will be prioritised) o Barthel Index o Functional Independence Measure o Other relevant scales • Arm function (continuous outcomes will be prioritised) o Fugl-Meyer assessment

		○ Other relevant scales • Arm muscle strength (continuous outcomes will be prioritised) ○ Motricity Index Score ○ Other relevant scales • Spasticity (continuous outcomes prioritised) ○ Modified Ashworth Scale ○ Tardaieu Scale ○ Patient-reported Impact of Spasticity Measure ○ Numeric Rating Scale for Spasticity ○ Modified Penn Spasm Frequency Scale • Stroke-specific Patient-Reported Outcome Measures (continuous outcomes will be prioritised) ○ Stroke-Specific Quality of Life (SS-QOL) ○ Stroke Impact Scale (SIS) ○ Stroke-specific Sickness Impact Profile (SA-SIP30) ○ Neuro-QOL ○ PROMIS-10 ○ Satisfaction with International Classification of Functioning, Disability and Health – Stroke (SATIS-Stroke) • Withdrawal for any reason (dichotomous outcome) • Adverse events (dichotomous outcomes) ○ Cardiovascular events ○ Injuries and pain ○ Other reported adverse events If not mentioned above, other validated scores will be considered and discussed with the committee to deliberate on their inclusion.
14.	Data extraction (selection and coding)	All references identified by the searches and from other sources will be uploaded into EPPI reviewer and de-duplicated. 10% of the abstracts will be reviewed by two reviewers, with any disagreements resolved by discussion or, if necessary, a third independent reviewer. The full text of potentially eligible studies will be retrieved and will be assessed in line with the criteria outlined above. A standardised form will be used to extract data from studies (see Developing NICE guidelines: the manual section 6.4).

		10% of all evidence reviews are quality assured by a senior research fellow. This includes checking: • papers were included /excluded appropriately • a sample of the data extractions • correct methods are used to synthesise data • a sample of the risk of bias assessments Disagreements between the review authors over the risk of bias in particular studies will be resolved by discussion, with involvement of a third review author where necessary. Study investigators may be contacted for missing data where time and resources allow.
15.	Risk of bias (quality) assessment	Risk of bias will be assessed using the appropriate checklist as described in Developing NICE guidelines: the manual. • Systematic reviews: Risk of Bias in Systematic Reviews (ROBIS) • Randomised Controlled Trial: Cochrane RoB (2.0) • Non randomised study, including cohort studies: Cochrane ROBINS-I • Case control study: CASP case control checklist
16.	Strategy for data synthesis	• Pairwise meta-analyses will be performed using Cochrane Review Manager (RevMan5). Fixed-effects (Mantel-Haenszel) techniques will be used to calculate risk ratios for the binary outcomes where possible. Continuous outcomes will be analysed using an inverse variance method for pooling weighted mean differences. Heterogeneity between the studies in effect measures will be assessed using the I^2 statistic and visually inspected. An I^2 value greater than 50% will be considered indicative of substantial heterogeneity. Sensitivity analyses will be conducted based on pre-specified subgroups using stratified meta-analysis to explore the heterogeneity in effect estimates. If this does not explain the heterogeneity, the results will be presented pooled using random-effects. • GRADEpro will be used to assess the quality of evidence for each outcome, taking into account individual study quality and the meta-analysis results. The 4 main quality elements (risk of bias, indirectness, inconsistency and imprecision) will be appraised for each outcome. Publication bias is tested for when there are more than 5 studies for an outcome. The risk of bias across all available evidence was evaluated for each outcome using an adaptation of

		the 'Grading of Recommendations Assessment, Development and Evaluation (GRADE) toolbox' developed by the international GRADE working group http://www.gradeworkinggroup.org/ • Where meta-analysis is not possible, data will be presented and quality assessed individually per outcome. • WinBUGS will be used for network meta-analysis, if possible given the data identified.
17.	Analysis of sub-groups	Subgroups that will be investigated if heterogeneity is present: Severity (as stated by category or as measured by NIHSS scale): • Mild (or NIHSS 1-5) • Moderate (or NIHSS 5-14) • Severe (or NIHSS 15-24) • Very severe (or NIHSS >25) Time after stroke at the start of the trial: • Hyperacute <72 hours • Acute 72 hours – 7 days • Subacute 7 days – 6 months • Chronic >6 months Region of upper limb trained • Distal limb • Proximal limb Dose (hours per day) • <1 hour • ≥1 hour Dose (days per week) • <5 days per week • ≥5 days per week Dose (duration) • <6 weeks • ≥6 weeks Level of supervision • Supervised • Unsupervised • Mixed Type of movement delivered by robotic device • Passive movement • Active assisted movement • Mixed

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<tr><td rowspan="8">18.</td><td rowspan="8">Type and method of review</td><td>☒</td><td colspan="2">Intervention</td></tr>
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<tr><td>21.</td><td>Anticipated or actual start date</td><td colspan="3">24/02/2021</td></tr>
<tr><td>22.</td><td>Anticipated completion date</td><td colspan="3">14/12/2022</td></tr>
<tr><td rowspan="8">23.</td><td rowspan="8">Stage of review at time of this submission</td><td>Review stage</td><td>Started</td><td>Completed</td></tr>
<tr><td>Preliminary searches</td><td>☐</td><td>☐</td></tr>
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<tr><td>Formal screening of search results against eligibility criteria</td><td>☐</td><td>☐</td></tr>
<tr><td>Data extraction</td><td>☐</td><td>☐</td></tr>
<tr><td>Risk of bias (quality) assessment</td><td>☐</td><td>☐</td></tr>
<tr><td>Data analysis</td><td>☐</td><td>☐</td></tr>
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<tr><td>24.</td><td>Named contact</td><td colspan="3">5a. Named contact
National Guideline Centre

5b Named contact e-mail
StrokeRehabUpdate@nice.nhs.uk

5e Organisational affiliation of the review
National Institute for Health and Care Excellence (NICE) and National Guideline Centre</td></tr>
<tr><td>25.</td><td>Review team members</td><td colspan="3">From the National Guideline Centre:
Bernard Higgins (Guideline lead)</td></tr>
</table>

		George Wood (Senior systematic reviewer) Madelaine Zucker (Systematic reviewer) Kate Lovibond (Health economics lead) Claire Sloan (Health economist) Joseph Runicles (Information specialist) Nancy Pursey (Senior project manager)
26.	Funding sources/sponsor	This systematic review is being completed by the National Guideline Centre which receives funding from NICE.
27.	Conflicts of interest	All guideline committee members and anyone who has direct input into NICE guidelines (including the evidence review team and expert witnesses) must declare any potential conflicts of interest in line with NICE's code of practice for declaring and dealing with conflicts of interest. Any relevant interests, or changes to interests, will also be declared publicly at the start of each guideline committee meeting. Before each meeting, any potential conflicts of interest will be considered by the guideline committee Chair and a senior member of the development team. Any decisions to exclude a person from all or part of a meeting will be documented. Any changes to a member's declaration of interests will be recorded in the minutes of the meeting. Declarations of interests will be published with the final guideline.
28.	Collaborators	Development of this systematic review will be overseen by an advisory committee who will use the review to inform the development of evidence-based recommendations in line with section 3 of Developing NICE guidelines: the manual. Members of the guideline committee are available on the NICE website: https://www.nice.org.uk/guidance/indevelopment/gid-ng10175
29.	Other registration details	N/A
30.	Reference/URL for published protocol	N/A
31.	Dissemination plans	NICE may use a range of different methods to raise awareness of the guideline. These include standard approaches such as: • notifying registered stakeholders of publication • publicising the guideline through NICE's newsletter and alerts • issuing a press release or briefing as appropriate, posting news articles on the NICE website, using social media channels, and publicising the guideline within NICE.
32.	Keywords	Adults; Intervention; Movement; Robot assisted arm training; Stroke; Upper limb

33.	Details of existing review of same topic by same authors	N/A	
34.	Current review status	☐	Ongoing
		☐	Completed but not published
		☒	Completed and published
		☐	Completed, published and being updated
		☐	Discontinued
35..	Additional information	N/A	
36.	Details of final publication	www.nice.org.uk	

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1 Health economic review protocol

Review question	All questions – health economic evidence
Objectives	To identify health economic studies relevant to any of the review questions.
Search criteria	• Populations, interventions and comparators must be as specified in the clinical review protocol above. • Studies must be of a relevant health economic study design (cost–utility analysis, cost-effectiveness analysis, cost–benefit analysis, cost–consequences analysis, comparative cost analysis). • Studies must not be a letter, editorial or commentary, or a review of health economic evaluations. (Recent reviews will be ordered although not reviewed. The bibliographies will be checked for relevant studies, which will then be ordered.) • Unpublished reports will not be considered unless submitted as part of a call for evidence. • Studies must be in English.
Search strategy	A health economic study search will be undertaken using population-specific terms and a health economic study filter – see appendix B below. Databases searched: • Centre for Reviews and Dissemination NHS Economic Evaluations Database (NHS EED) – all years (closed to new records April 2015) • Centre for Reviews and Dissemination Health Technology Assessment database – all years (closed to new records March 2018) • International HTA database (INAHTA) – all years • Medline and Embase – from 2014 (due to NHS EED closure)
Review strategy	Studies not meeting any of the search criteria above will be excluded. Studies published before 2006 (including those included in the previous guideline), abstract-only studies and studies from non-OECD countries or the USA will also be excluded. Each remaining study will be assessed for applicability and methodological limitations using the NICE economic evaluation checklist which can be found in appendix H of Developing NICE guidelines: the manual (2014).[80] Studies published in 2006 or later that were included in the previous guideline will be reassessed for inclusion and may be included or selectively excluded based on their relevance to the questions covered in this update and whether more applicable evidence is also identified. **Inclusion and exclusion criteria** • If a study is rated as both 'Directly applicable' and with 'Minor limitations' then it will be included in the guideline. A health economic evidence table will be completed, and it will be included in the health economic evidence profile. • If a study is rated as either 'Not applicable' or with 'Very serious limitations' then it will usually be excluded from the guideline. If it is excluded, then a health economic evidence table will not be completed and it will not be included in the health economic evidence profile. • If a study is rated as 'Partially applicable', with 'Potentially serious limitations' or both then there is discretion over whether it should be included. **Where there is discretion** The health economist will make a decision based on the relative applicability and quality of the available evidence for that question, in discussion with the guideline committee if required. The ultimate aim is to include health economic studies that are

	helpful for decision-making in the context of the guideline and the current NHS setting. If several studies are considered of sufficiently high applicability and methodological quality that they could all be included, then the health economist, in discussion with the committee if required, may decide to include only the most applicable studies and to selectively exclude the remaining studies. All studies excluded on the basis of applicability or methodological limitations will be listed with explanation in the excluded health economic studies appendix below. The health economist will be guided by the following hierarchies. *Setting:* • UK NHS (most applicable). • OECD countries with predominantly public health insurance systems (for example, France, Germany, Sweden). • OECD countries with predominantly private health insurance systems (for example, Switzerland). • Studies set in non-OECD countries or in the USA will be excluded before being assessed for applicability and methodological limitations. *Health economic study type:* • Cost–utility analysis (most applicable). • Other type of full economic evaluation (cost–benefit analysis, cost-effectiveness analysis, cost–consequences analysis). • Comparative cost analysis. • Non-comparative cost analyses including cost-of-illness studies will be excluded before being assessed for applicability and methodological limitations. *Year of analysis:* • The more recent the study, the more applicable it will be. • Studies published in 2006 or later (including any such studies included in the previous guideline) but that depend on unit costs and resource data entirely or predominantly from before 2006 will be rated as 'Not applicable'. • Studies published before 2006 (including any such studies included in the previous guideline) will be excluded before being assessed for applicability and methodological limitations. *Quality and relevance of effectiveness data used in the health economic analysis:* • The more closely the clinical effectiveness data used in the health economic analysis match with the outcomes of the studies included in the clinical review the more useful the analysis will be for decision-making in the guideline.

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Appendix B – Literature search strategies

B.1 Clinical search literature search strategy

Searches were constructed using a PICO framework where population (P) terms were combined with Intervention (I) and in some cases Comparison (C) terms. Outcomes (O) are rarely used in search strategies as these concepts may not be indexed or described in the title or abstract and are therefore difficult to retrieve. Search filters were applied to the search where appropriate.

Table 8: Database parameters, filters and limits applied

Database	Dates searched	Search filter used
Medline (OVID)	01 January 2018 – 08 January 2023	Randomised controlled trials Systematic review studies Exclusions (animal studies, letters, comments, editorials, case studies/reports) English language
Embase (OVID)	01 January 2018 – 08 January 2023	Randomised controlled trials Systematic review studies Exclusions (animal studies, letters, comments, editorials, case studies/reports, conference abstracts) English language
The Cochrane Library (Wiley)	Cochrane Reviews 2018 to 2023 Issue 1 of 12 CENTRAL 2018 to 2023 Issue 1 of 12	Exclusions (clinical trials, conference abstracts)
Epistemonikos (The Epistemonikos Foundation)	01 January 2018 – 08 January 2023	Exclusions (Cochrane reviews) English language
AMED, Allied and Complementary Medicine (OVID)	01 January 2018 – 08 January 2023	Exclusions (animal studies, letters, comments, case reports) English language
Current Nursing and Allied Health Literature - CINAHL (EBSCO)	01 January 2018 – 08 January 2023	Human Exclusions (Medline records) English Language

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2 **Medline (Ovid) search terms**

1.	exp Stroke/
2.	Stroke Rehabilitation/
3.	exp Cerebral Hemorrhage/
4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab,kf.
5.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab,kf.
6.	"brain attack*".ti,ab,kf.
7.	or/1-6
8.	exp upper extremity/
9.	(upper limb* or upper extremit* or upper body or arm or arms or shoulder or shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).ti,ab,kf.
10.	8 or 9
11.	7 and 10
12.	letter/
13.	editorial/
14.	news/
15.	exp historical article/
16.	Anecdotes as Topic/
17.	comment/
18.	case report/
19.	(letter or comment*).ti.
20.	or/12-19
21.	randomized controlled trial/ or random*.ti,ab.
22.	20 not 21
23.	animals/ not humans/
24.	exp Animals, Laboratory/
25.	exp Animal Experimentation/
26.	exp Models, Animal/
27.	exp Rodentia/
28.	(rat or rats or mouse or mice or rodent*).ti.
29.	or/22-28
30.	11 not 29
31.	limit 30 to English language
32.	robotics/ or automation/ or orthotic devices/ or Exoskeleton Device/ or Rehabilitation/is [Instrumentation]
33.	"equipment and supplies"/ or self-help devices/
34.	physical therapy modalities/ or occupational therapy/
35.	therapy, computer-assisted/ or man-machine systems/
36.	exercise movement techniques/ or exercise/ or exercise therapy/ or muscle stretching techniques/ or motion therapy, continuous passive/
37.	(robot* or orthos* or orthotic* or automat* or computer aided or computer assisted or device*).ti,ab,kf.
38.	(electromechanical or mechanical or mechanised or mechanized or driven).ti,ab,kf.

39.	((continuous passive or cpm) adj3 therap*).ti,ab,kf.
40.	(MIT-Manus or ARM guide or Bi-Manu-Track or ARMtrainer or MIME or Mirror Image Motion Enabler or InMOTION or REHAROB or NeReBot or "GEN-TLE/S" or ARMin).ti,ab,kf.
41.	(assist* adj5 (train* or aid* or rehabilitat* or re-educat*)).ti,ab,kf.
42.	or/32-41
43.	31 and 42
44.	randomized controlled trial.pt.
45.	controlled clinical trial.pt.
46.	randomi#ed.ti,ab.
47.	placebo.ab.
48.	randomly.ti,ab.
49.	Clinical Trials as topic.sh.
50.	trial.ti.
51.	or/44-50
52.	Meta-Analysis/
53.	exp Meta-Analysis as Topic/
54.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
55.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
56.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
57.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
58.	(search* adj4 literature).ab.
59.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
60.	cochrane.jw.
61.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
62.	or/52-61
63.	43 and (51 or 62)

1 **Embase (Ovid) search terms**

1.	exp Cerebrovascular accident/
2.	exp Brain infarction/
3.	Stroke Rehabilitation/
4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab,kf.
5.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab,kf.
6.	"brain attack*".ti,ab,kf.
7.	Intracerebral hemorrhage/
8.	or/1-7
9.	exp arm/ or arm weakness/ or arm exercise/ or arm movement/
10.	(upper limb* or upper extremit* or upper body or arm or arms or shoulder or shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).ti,ab,kf.
11.	or/9-10
12.	8 and 11
13.	letter.pt. or letter/

14.	note.pt.
15.	editorial.pt.
16.	case report/ or case study/
17.	(letter or comment*).ti.
18.	(conference abstract or conference paper).pt.
19.	or/13-18
20.	randomized controlled trial/ or random*.ti,ab.
21.	19 not 20
22.	animal/ not human/
23.	nonhuman/
24.	exp Animal Experiment/
25.	exp Experimental Animal/
26.	animal model/
27.	exp Rodent/
28.	(rat or rats or mouse or mice or rodent*).ti.
29.	or/21-28
30.	12 not 29
31.	limit 30 to English language
32.	robotics/ or automation/ or orthotics/ or "exoskeleton (rehabilitation)"/
33.	man machine interaction/ or biomedical engineering/ or device/ or machine/ or assistive technology/ or assistive technology device/ or computer assisted therapy/
34.	passive movement/ or movement therapy/ or kinesiotherapy/ or exp exercise/ or muscle stretching/ or muscle training/
35.	(robot* or orthos* or orthotic* or automat* or computer aided or computer assisted or device*).ti,ab,kf.
36.	(electromechanical or mechanical or mechanised or mechanized or driven).ti,ab,kf.
37.	((continuous passive or cpm) adj3 therap*).ti,ab,kf.
38.	(MIT-Manus or ARM guide or Bi-Manu-Track or ARMtrainer or MIME or Mirror Image Motion Enabler or InMOTION or REHAROB or NeReBot or "GEN-TLE/S" or ARMin).ti,ab,kf.
39.	(assist* adj5 (train* or aid* or rehabilitat* or re-educat*)).ti,ab,kf.
40.	or/32-39
41.	31 and 40
42.	random*.ti,ab.
43.	factorial*.ti,ab.
44.	(crossover* or cross over*).ti,ab.
45.	((doubl* or singl*) adj blind*).ti,ab.
46.	(assign* or allocat* or volunteer* or placebo*).ti,ab.
47.	crossover procedure/
48.	single blind procedure/
49.	randomized controlled trial/
50.	double blind procedure/
51.	or/42-50
52.	systematic review/
53.	meta-analysis/

54.	(meta analy* or metanaly* or metaanaly* or meta regression).ti,ab.
55.	((systematic* or evidence*) adj3 (review* or overview*)).ti,ab.
56.	(reference list* or bibliograph* or hand search* or manual search* or relevant journals).ab.
57.	(search strategy or search criteria or systematic search or study selection or data extraction).ab.
58.	(search* adj4 literature).ab.
59.	(medline or pubmed or cochrane or embase or psychlit or psyclit or psychinfo or psycinfo or cinahl or science citation index or bids or cancerlit).ab.
60.	cochrane.jw.
61.	((multiple treatment* or indirect or mixed) adj2 comparison*).ti,ab.
62.	Or/52-61
63.	41 and (51 or 62)

1 **Cochrane Library (Wiley) search terms**

#1.	MeSH descriptor: [Stroke] explode all trees
#2.	MeSH descriptor: [Stroke Rehabilitation] explode all trees
#3.	MeSH descriptor: [Cerebral Hemorrhage] explode all trees
#4.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident"):ti,ab
#5.	((cerebro* or brain or brainstem or cerebral*) near/3 (infarct* or accident*)):ti,ab
#6.	brain attack*:ti,ab
#7.	(or #1-#6)
#8.	conference:pt or (clinicaltrials or trialsearch):so
#9.	#7 not #8
#10.	MeSH descriptor: [Robotics] explode all trees
#11.	MeSH descriptor: [Automation] explode all trees
#12.	MeSH descriptor: [Orthotic Devices] explode all trees
#13.	MeSH descriptor: [Exoskeleton Device] explode all trees
#14.	MeSH descriptor: [Equipment and Supplies] this term only
#15.	MeSH descriptor: [Self-Help Devices] explode all trees
#16.	MeSH descriptor: [Physical Therapy Modalities] explode all trees
#17.	MeSH descriptor: [Occupational Therapy] explode all trees
#18.	MeSH descriptor: [Therapy, Computer-Assisted] explode all trees
#19.	MeSH descriptor: [Man-Machine Systems] explode all trees
#20.	MeSH descriptor: [Exercise Movement Techniques] explode all trees
#21.	MeSH descriptor: [Exercise] explode all trees
#22.	MeSH descriptor: [Exercise Therapy] explode all trees
#23.	MeSH descriptor: [Muscle Stretching Exercises] explode all trees
#24.	MeSH descriptor: [Motion Therapy, Continuous Passive] explode all trees
#25.	(robot* or orthos* or orthotic* or automat* or computer aided or computer assisted or device*):ti,ab
#26.	(electromechanical or mechanical or mechanised or mechanized or driven):ti,ab
#27.	((continuous passive or cpm) near/3 therap*):ti,ab
#28.	(MIT-Manus or ARM guide or Bi-Manu-Track or ARMtrainer or MIME or Mirror Image Motion Enabler or InMOTION or REHAROB or NeReBot or "GEN-TLE/S" or ARMin):ti,ab

#29.	(assist* near/5 (train* or aid* or rehabilitat* or re-educat*)):ti,ab
#30.	(or #10-#29)
#31.	#9 and #30
#32.	MeSH descriptor: [Upper Extremity] explode all trees
#33.	(upper limb* or upper extremit* or upper body or arm or arms or shoulder or shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*):ti,ab
#34.	(or #32-#33)
#35.	#31 and #34

1 **AMED search terms**

1.	exp Stroke/
2.	exp Cerebral Hemorrhage/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	or/1-5
7.	case report/
8.	(letter or comment*).ti.
9.	or/7-8
10.	randomized controlled trials/ or random*.ti,ab.
11.	9 not 10
12.	animals/ not humans/
13.	(rat or rats or mouse or mice or rodent*).ti.
14.	or/11-13
15.	6 not 14
16.	exp arm/
17.	(upper limb* or upper extremit* or upper body or arm or arms or shoulder or shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*).ti,ab.
18.	16 or 17
19.	15 and 18
20.	limit 19 to English language
21.	robotics/
22.	orthotic devices/
23.	physical therapy modalities/
24.	Exercise movement techniques/
25.	Exercise/
26.	Exercise therapy/
27.	continuous passive motion/
28.	(robot* or orthos* or orthotic* or automat* or computer aided or computer assisted or device*).ti,ab.
29.	(electromechanical or mechanical or mechanised or mechanized or driven).ti,ab.
30.	((continuous passive or cpm) adj3 therap*).ti,ab.
31.	(MIT-Manus or ARM guide or Bi-Manu-Track or ARMtrainer or MIME or Mirror Image Motion Enabler or InMOTION or REHAROB or NeReBot or "GEN-TLE/S" or ARMin).ti,ab.

32.	(assist* adj5 (train* or aid* or rehabilitat* or re-educat*)).ti,ab.
33.	or/21-32
34.	20 and 33

1 **CINAHL search terms**

S1.	MW Stroke or MH Cerebral Hemorrhage
S2.	stroke* or cva or poststroke* or apoplexy or "cerebrovascular accident"
S3.	(cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)
S4.	"brain attack*"
S5.	S1 or S2 or S3 or S4
S6.	MH upper extremity
S7.	upper limb* or upper extremit* or upper body or arm or arms or shoulder or shoulders or hand or hands or axilla* or elbow* or forearm* or finger* or wrist*
S8.	S6 or S7
S9.	S5 and S8
S10.	MH robotics
S11.	MH automation
S12.	MH occupational therapy
S13.	MH exercise
S14.	robot* or orthos* or orthotic* or automat* or computer aided or computer assisted or device*
S15.	electromechanical or mechanical or mechanised or mechanized or driven
S16.	continuous passive or cpm
S17.	MIT-Manus or ARM guide or Bi-Manu-Track or ARMtrainer or MIME or Mirror Image Motion Enabler or InMOTION or REHAROB or NeReBot or "GEN-TLE/S" or ARMin
S18.	S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17
S19.	S9 AND S18

2 **Epistemonikos search terms**

1.	(title:((title:((title:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*))) OR abstract:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*)))) OR (title:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))) OR abstract:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))))) OR abstract:((title:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*))) OR abstract:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*)))) OR (title:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))) OR abstract:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*)))))) AND (title:((title:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))) OR abstract:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))))) OR abstract:((title:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))) OR abstract:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))))))) OR abstract:((title:((title:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*))) OR abstract:((rehab*

	AND (hospital* OR patient* OR program* OR therap* OR assistant*)))) OR (title:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))) OR abstract:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))))) OR abstract:((title:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*))) OR abstract:((rehab* AND (hospital* OR patient* OR program* OR therap* OR assistant*)))) OR (title:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*))) OR abstract:(((intens* OR frequen* OR duration* OR period* OR time* OR timing OR hour* OR week* OR day*) AND (rehab* OR intervention*)))))) AND (title:((title:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))) OR abstract:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))))) OR abstract:((title:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)))) OR abstract:((stroke OR strokes OR cva OR poststroke* OR apoplexy OR "cerebrovascular accident" OR "brain attack*" OR ((cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*))))))) AND (title:(upper limb* OR upper extremit* OR upper body OR arm OR arms OR shoulder OR shoulders OR hand OR hands OR axilla* OR elbow* OR forearm* OR finger* OR wrist*) OR abstract:(upper limb* OR upper extremit* OR upper body OR arm OR arms OR shoulder OR shoulders OR hand OR hands OR axilla* OR elbow* OR forearm* OR finger* OR wrist*)) AND (title:(robot* OR orthos* OR orthotic* OR automat* OR computer aided OR computer assisted OR device*) OR abstract:(robot* OR orthos* OR orthotic* OR automat* OR computer aided OR computer assisted OR device*))

B.2 Health Economics literature search strategy

Health economic evidence was identified by conducting searches using terms for a broad Stroke Rehabilitation population. The following databases were searched: NHS Economic Evaluation Database (NHS EED - this ceased to be updated after 31st March 2015), Health Technology Assessment database (HTA - this ceased to be updated from 31st March 2018) and The International Network of Agencies for Health Technology Assessment (INAHTA). Searches for recent evidence were run on Medline and Embase from 2014 onwards for health economics, and all years for quality-of-life studies. Additional searches were run in CINAHL and PsycInfo looking for health economic evidence.

Table 2: Database parameters, filters and limits applied

Database	Dates searched	Search filters and limits applied
Medline (OVID)	Health Economics 1 January 2014 – 08 January 2023	Health economics studies Quality of life studies Exclusions (animal studies, letters, comments, editorials, case studies/reports,) English language
	Quality of Life 1946 – 08 January 2023	
Embase (OVID)	Health Economics 1 January 2014 – 08 January 2023	Health economics studies Quality of life studies

Database	Dates searched	Search filters and limits applied
		Exclusions (animal studies, letters, comments, editorials, case studies/reports, conference abstracts) English language
	Quality of Life 1974 – 08 January 2023	
NHS Economic Evaluation Database (NHS EED) (Centre for Research and Dissemination - CRD)	Inception –31st March 2015	
Health Technology Assessment Database (HTA) (Centre for Research and Dissemination – CRD)	Inception – 31st March 2018	
The International Network of Agencies for Health Technology Assessment (INAHTA)	Inception - 08 January 2023	English language
PsycINFO (OVID)	1 January 2014 – 08 January 2023	Health economics studies Exclusions (animal studies, letters, case reports) Human English language
Current Nursing and Allied Health Literature - CINAHL (EBSCO)	1 January 2014 – 08 January 2023	Health economics studies Exclusions (Medline records, animal studies, letters, editorials, comments, theses) Human English language

1 **Medline (Ovid) search terms**

1.	exp Stroke/
2.	exp Cerebral Hemorrhage/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	or/1-5
7.	letter/
8.	editorial/

9.	news/
10.	exp historical article/
11.	Anecdotes as Topic/
12.	comment/
13.	case report/
14.	(letter or comment*).ti.
15.	or/7-14
16.	randomized controlled trial/ or random*.ti,ab.
17.	15 not 16
18.	animals/ not humans/
19.	exp Animals, Laboratory/
20.	exp Animal Experimentation/
21.	exp Models, Animal/
22.	exp Rodentia/
23.	(rat or rats or mouse or mice or rodent*).ti.
24.	or/17-23
25.	6 not 24
26.	Economics/
27.	Value of life/
28.	exp "Costs and Cost Analysis"/
29.	exp Economics, Hospital/
30.	exp Economics, Medical/
31.	Economics, Nursing/
32.	Economics, Pharmaceutical/
33.	exp "Fees and Charges"/
34.	exp Budgets/
35.	budget*.ti,ab.
36.	cost*.ti.
37.	(economic* or pharmaco?economic*).ti.
38.	(price* or pricing*).ti,ab.
39.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
40.	(financ* or fee or fees).ti,ab.
41.	(value adj2 (money or monetary)).ti,ab.
42.	or/26-41
43.	quality-adjusted life years/
44.	sickness impact profile/
45.	(quality adj2 (wellbeing or well being)).ti,ab.
46.	sickness impact profile.ti,ab.
47.	disability adjusted life.ti,ab.

48.	(qal* or qtime* or qwb* or daly*).ti,ab.
49.	(euroqol* or eq5d* or eq 5*).ti,ab.
50.	(qol* or hql* or hqol* or h qol* or hrqol* or hr qol*).ti,ab.
51.	(health utility* or utility score* or disutilit* or utility value*).ti,ab.
52.	(hui or hui1 or hui2 or hui3).ti,ab.
53.	(health* year* equivalent* or hye or hyes).ti,ab.
54.	discrete choice*.ti,ab.
55.	rosser.ti,ab.
56.	(willingness to pay or time tradeoff or time trade off or tto or standard gamble*).ti,ab.
57.	(sf36* or sf 36* or short form 36* or shortform 36* or shortform36*).ti,ab.
58.	(sf20 or sf 20 or short form 20 or shortform 20 or shortform20).ti,ab.
59.	(sf12* or sf 12* or short form 12* or shortform 12* or shortform12*).ti,ab.
60.	(sf8* or sf 8* or short form 8* or shortform 8* or shortform8*).ti,ab.
61.	(sf6* or sf 6* or short form 6* or shortform 6* or shortform6*).ti,ab.
62.	or/43-61
63.	25 and 42
64.	25 and 62
65.	limit 63 to English language
66.	limit 64 to English language

1 **Embase (Ovid) search terms**

1.	exp Cerebrovascular accident/
2.	exp Brain infarction/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	Intracerebral hemorrhage/
7.	or/1-6
8.	letter.pt. or letter/
9.	note.pt.
10.	editorial.pt.
11.	case report/ or case study/
12.	(letter or comment*).ti.
13.	or/8-12
14.	randomized controlled trial/ or random*.ti,ab.
15.	13 not 14
16.	animal/ not human/
17.	nonhuman/
18.	exp Animal Experiment/
19.	exp Experimental Animal/

20.	animal model/
21.	exp Rodent/
22.	(rat or rats or mouse or mice).ti.
23.	or/15-22
24.	7 not 23
25.	health economics/
26.	exp economic evaluation/
27.	exp health care cost/
28.	exp fee/
29.	budget/
30.	funding/
31.	budget*.ti,ab.
32.	cost*.ti.
33.	(economic* or pharmaco?economic*).ti.
34.	(price* or pricing*).ti,ab.
35.	(cost* adj2 (effective* or utilit* or benefit* or minimi* or unit* or estimat* or variable*)).ab.
36.	(financ* or fee or fees).ti,ab.
37.	(value adj2 (money or monetary)).ti,ab.
38.	or/25-37
39.	quality adjusted life year/
40.	"quality of life index"/
41.	short form 12/ or short form 20/ or short form 36/ or short form 8/
42.	sickness impact profile/
43.	(quality adj2 (wellbeing or well being)).ti,ab.
44.	sickness impact profile.ti,ab.
45.	disability adjusted life.ti,ab.
46.	(qal* or qtime* or qwb* or daly*).ti,ab.
47.	(euroqol* or eq5d* or eq 5*).ti,ab.
48.	(qol* or hql* or hqol* or h qol* or hrqol* or hr qol*).ti,ab.
49.	(health utility* or utility score* or disutilit* or utility value*).ti,ab.
50.	(hui or hui1 or hui2 or hui3).ti,ab.
51.	(health* year* equivalent* or hye or hyes).ti,ab.
52.	discrete choice*.ti,ab.
53.	rosser.ti,ab.
54.	(willingness to pay or time tradeoff or time trade off or tto or standard gamble*).ti,ab.
55.	(sf36* or sf 36* or short form 36* or shortform 36* or shortform36*).ti,ab.
56.	(sf20 or sf 20 or short form 20 or shortform 20 or shortform20).ti,ab.
57.	(sf12* or sf 12* or short form 12* or shortform 12* or shortform12*).ti,ab.
58.	(sf8* or sf 8* or short form 8* or shortform 8* or shortform8*).ti,ab.
59.	(sf6* or sf 6* or short form 6* or shortform 6* or shortform6*).ti,ab.
60.	or/39-59

61.	limit 24 to English language
62.	38 and 61
63.	60 and 61

1 NHS EED and HTA (CRD) search terms

#1.	MeSH DESCRIPTOR Stroke EXPLODE ALL TREES
#2.	MeSH DESCRIPTOR Cerebral Hemorrhage EXPLODE ALL TREES
#3.	(stroke* or cva or poststroke* or apoplexy or "cerebrovascular accident")
#4.	(((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)))
#5.	("brain attack*")
#6.	#1 OR #2 OR #3 OR #4 OR #5

2 INAHTA search terms

1.	(brain attack*) OR (((cerebro* or brain or brainstem or cerebral*) and (infarct* or accident*))) OR ((stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident")) OR ("Cerebral Hemorrhage"[mhe]) OR ("Stroke"[mhe])

3 CINAHL search terms

1.	MH "Economics+"
2.	MH "Financial Management+"
3.	MH "Financial Support+"
4.	MH "Financing, Organized+"
5.	MH "Business+"
6.	S2 OR S3 or S4 OR S5
7.	S1 not S6
8.	MH "Health Resource Allocation"
9.	MH "Health Resource Utilization"
10.	S8 OR S9
11.	S7 OR S10
12.	(cost or costs or economic* or pharmacoeconomic* or price* or pricing*) OR AB (cost or costs or economic* or pharmacoeconomic* or price* or pricing*)
13.	S11 OR S12
14.	PT editorial
15.	PT letter
16.	PT commentary
17.	S14 or S15 or S16
18.	S13 NOT S17
19.	MH "Animal Studies"
20.	(ZT "doctoral dissertation") or (ZT "masters thesis")
21.	S18 NOT (S19 OR S20)
22.	PY 2014-
23.	S21 AND S22
24.	MW Stroke or MH Cerebral Hemorrhage
25.	stroke* or cva or poststroke* or apoplexy or "cerebrovascular accident"
26.	(cerebro* OR brain OR brainstem OR cerebral*) AND (infarct* OR accident*)

27.	"brain attack*"
28.	S24 OR S25 OR S26 OR S27
29.	S23 AND S28

1 **PsycINFO search terms**

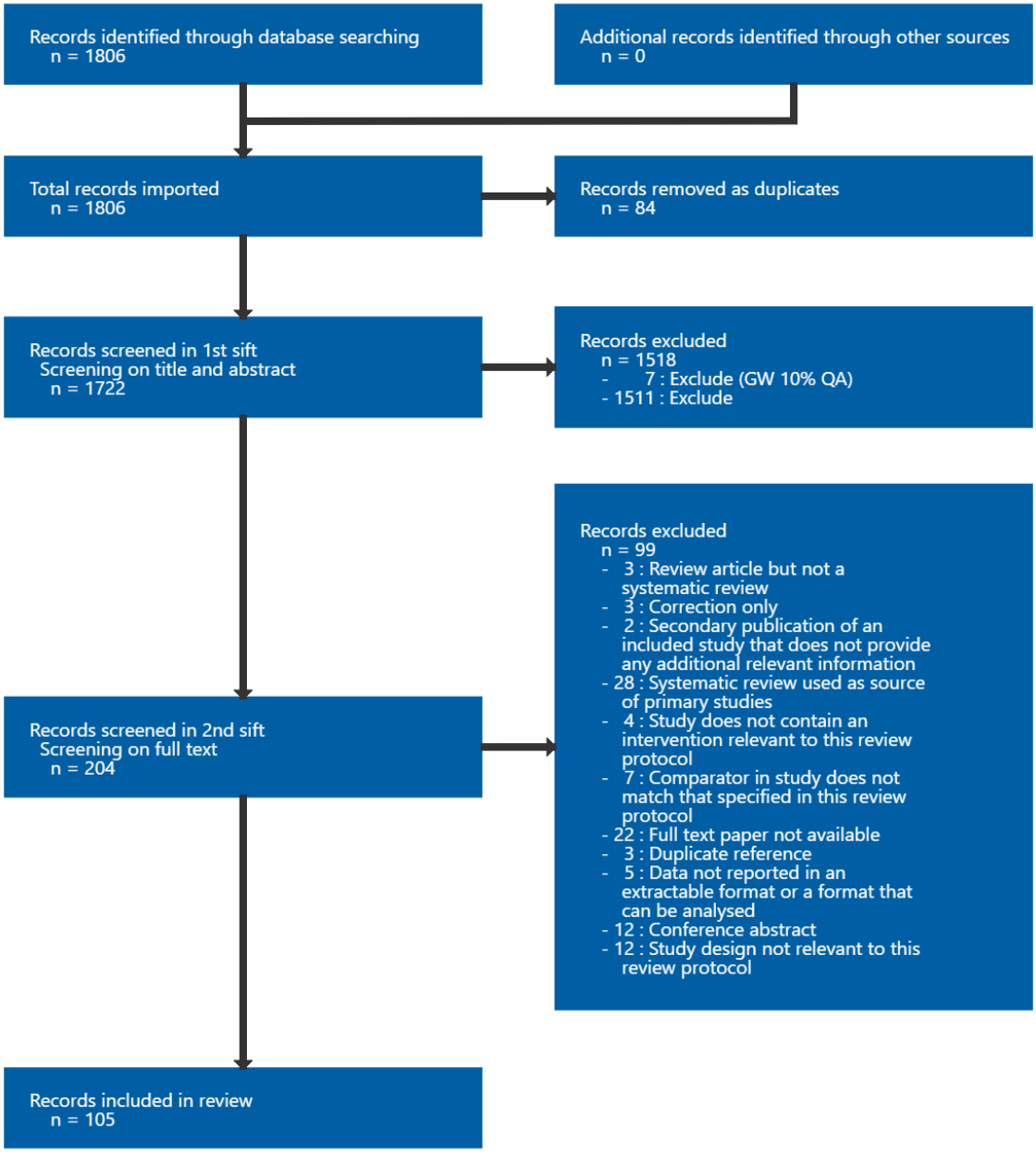
1.	exp Stroke/
2.	exp Cerebral hemorrhage/
3.	(stroke or strokes or cva or poststroke* or apoplexy or "cerebrovascular accident").ti,ab.
4.	((cerebro* or brain or brainstem or cerebral*) adj3 (infarct* or accident*)).ti,ab.
5.	"brain attack*".ti,ab.
6.	Cerebrovascular accidents/
7.	exp Brain damage/
8.	(brain adj2 injur*).ti.
9.	or/1-8
10.	Letter/
11.	Case report/
12.	exp Rodents/
13.	or/10-12
14.	9 not 13
15.	limit 14 to (human and english language)
16.	First posting.ps.
17.	15 and 16
18.	15 or 17
19	"costs and cost analysis"/
20.	"Cost Containment"/
21.	(economic adj2 evaluation$).ti,ab.
22.	(economic adj2 analy$).ti,ab.
23.	(economic adj2 (study or studies)).ti,ab.
24.	(cost adj2 evaluation$).ti,ab.
25.	(cost adj2 analy$).ti,ab.
26.	(cost adj2 (study or studies)).ti,ab.
27.	(cost adj2 effective$).ti,ab.
28.	(cost adj2 benefit$).ti,ab.
29.	(cost adj2 utili$).ti,ab.
30.	(cost adj2 minimi$).ti,ab.
31.	(cost adj2 consequence$).ti,ab.
32.	(cost adj2 comparison$).ti,ab.
33.	(cost adj2 identificat$).ti,ab.
34.	(pharmacoeconomic$ or pharmaco-economic$).ti,ab.
35.	or/19-34
36.	(0003-4819 or 0003-9926 or 0959-8146 or 0098-7484 or 0140-6736 or 0028-4793 or 1469-493X).is.

37.	35 not 36
38.	18 and 37

1
2

Appendix C – Effectiveness evidence study selection

Figure 1: Flow chart of clinical study selection for the review of robot assisted arm training



Appendix D – Effectiveness evidence

Abdollahi, 2018

Bibliographic Reference	Abdollahi, F.; Corrigan, M.; Lazzaro, E. D. C.; Kenyon, R. V.; Patton, J. L.; Error-augmented bimanual therapy for stroke survivors; Neurorehabilitation; 2018; vol. 43 (no. 1); 51-61

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	NCT01574495
Study type	Randomised controlled trial (RCT)
Study location	USA
Study setting	outpatient rehabilitation hospital
Study dates	NR
Sources of funding	NR

Inclusion criteria	Eligible participants were all adults aged 18 or over and had suffered a single hemispheric stroke at least six months prior to enrollment. Participation also required some recovery of proximal strength in the hemiparetic limb as confirmed by an upper extremity Fugl-Meyer score of 25–50.
Exclusion criteria	Participants were excluded if there was multiple strokes, bilateral paresis, severe spasticity or contracture, severe concurrent medical problems, severe sensory deficits, cerebellar strokes resulting in severe ataxia, significant shoulder pain, focal tone management with botulinim toxin injection to the hemiparetic upper extremity within the previous four months, depth perception impairment (<3/9 on Stereo Circle Test), visual field cut, cognitive impairment (Mini Mental State Examination <23/30), or if the patient had severe aphasia, affective dysfunction, or hemisensory neglect that would influence the ability to perform the experiment or provide informed consent. Participants were also excluded if they were currently receiving any other skilled upper extremity rehabilitation in a clinical setting.
Recruitment / selection of participants	Study participants were recruited from a registry of post-stroke individuals or who responded to local flyer postings.
Intervention(s)	Error-augmented (E-A) bimanual therapy n=12 For all participants, each session began with five minutes to position the participant in the apparatus, then six 5-minute blocks of training with two-minutes of rest between each block. The blocks alternated, and were either bimanual targeted-reaching or free bimanual practice. Targeted reaching blocks involved attempts to reach from a location above the centers of the thighs out both to one of 4 target sets, and then stop for at least a half-second. The system allowed 3 seconds to make this motion, at which point the system cued a return to the starting point and proceeded to the next motion. The targets were spaced evenly in the reaching workspace and were also meant to probe the patient's range of motion. If subjects successfully attained more than 70% of the targets on any block, the targets were moved 20% more distant. The free movement blocks were meant to address participants' self-tailored ideas of therapy, which included the possibility of choosing the previous standardized five-minute block for practice. This allowed the participants to partially customize their own therapy, focusing on their perceived deficits. Quantitative assessments were performed at the beginning and end of the treatment (pre- and post-) as well as one week after the post-treatment assessment (follow-up). During all sessions, participants were seated in a chair with the hemiparetic arm supported by the WREX™ gravity-balanced orthosis. One cursor displayed the movement of left hand, another cursor displayed the right. The hemiparetic hand was placed in an exotendon glove that assisted with a functional hand and wrist position. The robot was connected

	near the wrist joint center to allow the hand to open freely as well as allow free pronation and supination of the forearm. Both the PHANTOM™ robot and the position tracker were attached to the affected and non-affected forearms respectively, with the center of the devices located above the radiocarpal joint. The error augmenting treatment involved subtle, haptic error-augmenting forces were applied by the robot during the EA treatment but not in non-EA treatment. Participants were instructed to keep moving their arms together as much as possible while reaching to targets throughout the workspace. For the EA treatment, the error vector, defined as the instantaneous difference in position between the participant's wrists was visually magnified by a factor of 1.5 as part of the error augmentation. Additionally, an error augmenting force of 100 N/m was applied pushing the participant's affected hand further away from the non-affected hand. For safety purposes, this force was designed to saturate at a maximum of 4 Newtons. Concomitant therapy: not reported.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement	Not stated/unclear

delivered by robotic device	
Population subgroups	NR
Comparator	Non error augmented (non-EA) bimanual therapy n=10 Each group had the same amount of practice in two weeks of training with three, 45-minute sessions per week (six sessions total). As per the intervention group, but without error augmentation.
Number of participants	26
Duration of follow-up	1 week after the end of treatment.
Indirectness	N/A

Study arms

Bilateral arm training with error augmentation (robot attached and used) (N = 12)
Duration 2 weeks. Three 45 minute sessions per week (six sessions total).

Bimanual training without error augmentation (robot attached but was not used) (N = 10)
Duration 2 weeks. Three 45 minute sessions per week (six sessions total).

Characteristics

Study-level characteristics

Characteristic	Study (N = 26)
% Female No of events	n = 8 ; % = 31
Mean age (SD) Mean (SD)	53.86 (NR)

Outcomes

Study timepoints

- Baseline
- 3 week (1 week post-intervention)

Dichotomous outcome

Outcome	Bilateral arm training with error augmentation (robot attached and used), Baseline, N = 12	Bilateral arm training with error augmentation (robot attached and used), 3 week, N = 12	Bimanual training without error augmentation (robot attached but was not used), Baseline, N = 10	Bimanual training without error augmentation (robot attached but was not used), 3 week, N = 10
Withdrawal for any reason Both were due to medical issues not related to treatment.	n = NA ; % = NA	n = 2 ; % = 17	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Bilateral arm training with error augmentation (robot attached and used), Baseline, N = 12	Bilateral arm training with error augmentation (robot attached and used), 3 week, N = 12	Bimanual training without error augmentation (robot attached but was not used), Baseline, N = 10	Bimanual training without error augmentation (robot attached but was not used), 3 week, N = 10
No of events				

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Bilateral arm training with error augmentation (robot attached and used)-Bimanual training without error augmentation (robot attached but was not used)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Both groups received robot therapy but only the intervention group received error augmentation.)*

Abdullah, 2011

Bibliographic Reference	Abdullah, Hussein A.; Tarry, Cole; Lambert, Cynthia; Barreca, Susan; Allen, Brian O.; Results of clinicians using a therapeutic robotic system in an inpatient stroke rehabilitation unit; Journal of neuroengineering and rehabilitation; 2011; vol. 8 (no. 1); 1-12

1 **Study details**

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed Starting with passive and moving up to active assisted

2

Study arms

Robot-mediated therapy (N = 9)
45 minutes, 3 times a week for 8-11 weeks

Conventional arm therapy (N = 11)
45 minutes, 3 times a week for 8-11 weeks

Outcomes

Study timepoints
- Baseline
- 11 week (Post-intervention)

Continuous outcome

Outcome	Robot-mediated therapy, Baseline, N = 9	Robot-mediated therapy, 11 week, N = 9	Conventional arm therapy, Baseline, N = 11	Conventional arm therapy, 11 week, N = 11
Arm function (Chedoke Arm and Hand Activity Inventory CAHAI-7) Scale range: Unclear, likely 1-7. Final values. Values reported in the Cochrane review used. Mean (SD)	NR (NR)	2.75 (1.8)	NR (NR)	1 (1.69)

Arm function (Chedoke Arm and Hand Activity Inventory CAHAI-7) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(ChedokeArmandHandActivityInventoryCAHAI-7)-MeanSD-Robot-mediated therapy-Conventional arm therapy-t11

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Amirabdollahian, 2007

Bibliographic Reference	Amirabdollahian, Farshid; Loureiro, Rui; Gradwell, Elizabeth; Collin, Christine; Harwin, William; Johnson, Garth; Multivariate analysis of the Fugl-Meyer outcome measures assessing the effectiveness of GENTLE/S robot-mediated stroke therapy; Journal of neuroengineering and rehabilitation; 2007; vol. 4 (no. 1); 1-16

Study details

Secondary publication of another included study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour Three ten minute sessions over two weeks
Subgroup 5: Dose (days per week)	<5 days per week Three ten minute sessions over two weeks
Subgroup 6: Dose (duration)	<6 weeks Three ten minute sessions over two weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot-mediated therapy (N = 16)
ABC - 3 weeks at baseline (phase A), then 3 weeks robot-mediated therapy (phase B) then 3 weeks sling suspension (phase C). Follow up at 6 weeks.

Sling suspension (non-robot therapy) (N = 15)

ACB - 3 weeks at baseline (phase A), then 3 weeks sling suspension (phase C), then 3 weeks robot-mediated therapy. Follow up at 6 weeks.

Outcomes

Study timepoints

- Baseline
- 6 week (End of intervention (only including first phase of crossover trial))

Dichotomous outcome

Outcome	Robot-mediated therapy, Baseline, N = 16	Robot-mediated therapy, 6 week, N = 16	Sling suspension (non-robot therapy), Baseline, N = 15	Sling suspension (non-robot therapy), 6 week, N = 15
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Sling suspension (non-robot therapy)-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Ang, 2014

Bibliographic Reference	Ang, Kai Keng; Guan, Cuntai; Phua, Kok Soon; Wang, Chuanchu; Zhou, Longjiang; Tang, Ka Yin; Ephraim Joseph, Gopal J.; Kuah, Christopher Wee Keong; Chua, Karen Sui Geok; Brain-computer interface-based robotic end effector system for wrist and hand rehabilitation: results of a three-armed randomized controlled trial for chronic stroke; Frontiers in neuroengineering; 2014; vol. 7; 30

Study details

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Mixed total mean FMMA at baseline: 27.0 (13.8)
Subgroup 2: Time after stroke at the start of the trial	Mixed

	>4 months subacute and chronic.
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot-mediated therapy (N = 15)
group 1: robot-mediated therapy with the haptic knob robot and a brain computer interface for 60 minutes + therapist-assisted arm mobilisation for 30 minutes Total of 18 sessions over 6 weeks, 3 times per week, 90 min per session. group 2: robot-mediated therapy with the haptic knob robot alone for 60 minutes + therapist-assisted arm mobilisation for 30 minutes We combined the results of both HK groups in 1 (collapsed) group and compared this collapsed group with the results of the standard arm therapy group

Standard arm therapy (N = 7)
Standard arm therapy for 60 minutes + therapist-assisted arm mobilisation for 30 minutes. Total of 18 sessions over 6 weeks, 3 times per week, 90 min per session.

Outcomes

Study timepoints
- Baseline
- 6 week (End of intervention)
- 18 week (Longest follow-up (post-intervention))

Continuous outcomes

Outcome	Robot-mediated therapy, Baseline, N = 15	Robot-mediated therapy, 6 week, N = 15	Robot-mediated therapy, 18 week, N = 15	Standard arm therapy, Baseline, N = 7	Standard arm therapy, 6 week, N = 7	Standard arm therapy, 18 week, N = 7
Arm function (Fugl-Meyer assesment) Scale range: 0-66. Change scores. Values reported in the Cochrane review used. Mean (SD)	30.5 (15.2)	7.3 (3.5)	9.2 (3.8)	23.4 (14.5)	4.9 (4.1)	3.6 (5.9)

Arm function (Fugl-Meyer assesment) - Polarity - Higher values are better
Change scores. Baseline values (FM): BCI+HK group: 33.0 (16.2), HK group: 25.5 (11.5); 6 week values: BCI+HK group: 7.2 (2.3), HK group: 7.3 (4.7); 18 week values BCI+HK group: 9.7 (2.9), HK group: 8.3 (5.0) Robot groups were combined for analysis. Also reports FM outcome by proximal and distal limb.

Dichotomous outcomes

Outcome	Robot-mediated therapy, Baseline, N = 15	Robot-mediated therapy, 6 week, N = 15	Robot-mediated therapy, 18 week, N = 15	Standard arm therapy, Baseline, N = 7	Standard arm therapy, 6 week, N = 7	Standard arm therapy, 18 week, N = 7
Adverse events No of events	n = NA	n = 1	n = 0	n = NA	n = 0	n = 0
Withdrawal for any reason No of events	n = NA ; % = NA	n = 1	n = NA ; % = NA	n = NA ; % = NA	n = 0	n = NA ; % = NA

One participant in the robot therapy group dropped out on the 5th week of the intervention due to a transient mild seizure occurring several hours after the intervention (same participant recorded as adverse event and withdrawal).

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassesment),changescores-MeanSD-Robot-mediated therapy-Standard arm therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassesment)-MeanSD-Robot-mediated therapy-Standard arm therapy-t18

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Standard arm therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Standard arm therapy-t18

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Aprile, 2020

Bibliographic Reference	Aprile, I.; Germanotta, M.; Cruciani, A.; Loreti, S.; Pecchioli, C.; Cecchi, F.; Montesano, A.; Galeri, S.; Diverio, M.; Falsini, C.; Speranza, G.; Langone, E.; Papadopoulou, D.; Padua, L.; Carrozza, M. C.; Group, F. D. G. Robotic Rehabilitation; Upper Limb Robotic Rehabilitation After Stroke: A Multicenter, Randomized Clinical Trial; Journal of Neurologic Physical Therapy; 2020; vol. 44 (no. 1); 3-14

Study details

Secondary publication of another included study- see primary study for details	NA
Other publications associated with this study included in review	Padua L, Imbimbo I, Aprile I, Loreti C, Germanotta M, Coraci D, Piccinini G, Pazzaglia C, Santilli C, Cruciani A, Carrozza MC; FDG Robotic Rehabilitation Group†. Cognitive reserve as a useful variable to address robotic or conventional upper limb rehabilitation treatment after stroke: a multicentre study of the Fondazione Don Carlo Gnocchi. Eur J Neurol. 2020 Feb;27(2):392-398. doi: 10.1111/ene.14090. Epub 2019 Oct 18. PMID: 31536677.
Trial name / registration number	(NCT02879279)
Study location	Italy
Study setting	The study was conducted in 8 rehabilitation centers of the Fondazione Don Carlo Gnocchi, in Italy.
Study dates	August 2016 to March 2018.
Sources of funding	NR
Inclusion criteria	subjects with 1 ischemic or hemorrhagic stroke (verified by MRI or CT), aged between 40 and 85 years, with a time since stroke ranging from 2 weeks to 6 months (ie, after the acute phase)1 and cognitive and language abilities adequate to understand the experiments and the follow instructions. Subjects' upper extremity Fugl-Meyer Assessment (FMA) score (0-66 version) had to be 58 or less
Exclusion criteria	Exclusion criteria were behavioural and cognitive disorders and/or reduced compliance, fixed contraction in the affected limb (ankylosis, Modified Ashworth Scale equal to 4), and severe deficits in visual acuity.
Recruitment / selection of participants	We recruited consecutive subjects with 1 ischemic or haemorrhagic stroke (verified by MRI or CT).

Intervention(s)	In the RG, both the distal and the proximal segments of the subjects' UL were treated by means of robotic and sensor based devices. Specifically, subjects were treated with the following systems: (a) a robotic device that allows passive, active, and active-assistive planar movements of the shoulder and elbow joints (Motore, Humanware, Italy); (b) a robotic device that allows passive, active, and active-assistive finger flexion and extension movements (Amadeo, Tyromotion, Austria); (c) a sensor-based system that allows unsupported 3-dimensional movements of shoulder, elbow, and wrist joint, both unimanual and bimanual (Pablo, Tyromotion, Austria); and (d) a robotic system that allows 3-dimensional, unimanual and bimanual, movements of the shoulder joint, with arm weight support (Diego, Tyromotion, Austria). During the treatment, subjects performed both motor and cognitive tasks, and the devices provided visual and auditory feedback. In addition, a vibratory treatment (with a frequency of 60 Hz) was applied, using the Amadeo system, to increase the proprioception of the hand, before the finger training. The experimental treatment was aligned among the centers in terms of protocol and intensity. During the treatment, a group of 3 subjects was supervised by 1 therapist. During each session, the physical therapist used 1 system for each subject, to minimize the time required to move the subjects from one system to another. The rehabilitation program started with the robotic device for the shoulder and elbow joints, followed by the robotic device for the hand, the sensor-based device for the shoulder, elbow, and wrist, and, finally, the robotic system for the shoulder. The adopted protocol provided general guidelines, which were organized into a flowchart, in order to ensure the homogeneity of treatment. However, the physical therapist selected and adapted the exercises, in term of workspace and difficulty, to the subject's residual ability. Concomitant therapy - In both groups, the treatment was performed daily for 45 minutes, 5 days a week, for a total of 30 sessions. In addition to the UL rehabilitation session (according to the allocated group), all subjects underwent conventional rehabilitation sessions (6 times/week), lasting 45 minutes, focused on lower limb, sitting and standing training, balance, and walking. Subjects underwent occupational and speech therapy, if needed. To avoid the possibility of performance bias, the therapists who treated the subjects in the RG were different from therapists who treated the subjects in the CG.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed

Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	NR
Comparator	In the CG, subjects underwent a conventional treatment, with a ratio of 1 therapist to 1 subject, that followed the guidelines provided in literature. The therapeutic task focused on functional improvement, including task-oriented exercises, sensorimotor reorganization, and spasticity inhibition. Subjects performed passive, active, and active-assisted exercises on the 3 UL joints, in the 3-dimensional space, to improve joint function, to prevent contractures, to inhibit spasticity, and to improve motor function. The therapeutic task focused on functional improvement, sensorimotor reorganization, and spasticity inhibition. Subjects performed passive, active, and active-assisted exercises on the 3 UL joints, in the 3-dimensional space to gain strength and motor function, improve joint range of motion, prevent contractures, and inhibit spasticity. They also performed task-oriented exercises included reaching and grasping movements (eg, reaching and picking up a glass or other objects), activities of daily living (eg, transfers, dressing, brushing/combing hair, according to subject's ability), to increase the subject's participation so as to promote neuroplasticity and improve upper limp motor recovery. At the first treatment session each subject underwent an UL evaluation aimed to personalize the rehabilitation program and determine the exercises to deliver. Each therapist was free to adapt every rehabilitation session to the subject, according to their functional assessment and needs. Therefore, each activity duration, specific number of repetitions or difficulty of exercise to be performed during a conventional rehabilitation session was not predefined in the protocol.
Number of participants	247

Duration of follow-up	6 weeks immediately post intervention
Indirectness	NR
Additional comments	NR

Study arms

robotic group (N = 123)

conventional group (N = 124)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 247)**
Ethnicity Nominal	NR
Comorbidities Nominal	NR
Severity Nominal	NR

Arm-level characteristics

Characteristic	robotic group (N = 123)	conventional group (N = 124)
% Female Nominal	43.2	43.4
Mean age (SD) Mean (SD)	69.5 (10.9)	68.5 (11.5)
Time after stroke Nominal	NR	NR
15-30 days Nominal	51.4	53.1
31-90 days Nominal	35.1	31.9
91-180 days Nominal	13.5	15

Outcomes

Study timepoints

- Baseline
- 6 week

continuous outcomes

Outcome	robotic group, Baseline, N = 123	robotic group, 6 week, N = 91	conventional group, Baseline, N = 124	conventional group, 6 week, N = 99
Arm function (FMA UE) 0-66 change score Mean (95% CI)	NR (NR to NR)	8.5 (6.82 to 10.17)	NR (NR to NR)	8.57 (6.97 to 10.18)
Arm strength (Motricity Index) 0-100, change score Mean (95% CI)	NR (NR to NR)	17.35 (14.35 to 20.34)	NR (NR to NR)	12.92 (10.05 to 15.79)
Arm strength (Motricity Index) 0-100, change score Mean (SD)	37.6 (27.6)	NR (NR)	33.2 (28.8)	NR (NR)
Person/participant generic health related quality of life (SF-36 MCS) (intervention N= 89, control N = 91) 0-100, change score Mean (95% CI)	NR (NR to NR)	3.15 (1.18 to 5.11)	NR (NR to NR)	4.46 (2.52 to 6.4)
Person/participant generic health related quality of life (SF-36 MCS) (intervention N= 89, control N = 91) 0-100, change score Mean (SD)	41.8 (12.2)	NR (NR)	40 (12)	NR (NR)
Person/participant generic health related quality of life (SF-36 PCS) 0-100, change score Mean (95% CI)	NR (NR to NR)	1.66 (0.48 to 2.84)	NR (NR to NR)	1.37 (0.2 to 2.54)

Outcome	robotic group, Baseline, N = 123	robotic group, 6 week, N = 91	conventional group, Baseline, N = 124	conventional group, 6 week, N = 99
Person/participant generic health related quality of life (SF-36 PCS) 0-100, change score Mean (SD)	26.6 (7.2)	NR (NR)	28.1 (6.7)	NR (NR)
Activities of daily living (Modified Barthel Index) 0-100, change score Mean (SD)	34.3 (25.8)	NR (NR)	33 (27.5)	NR (NR)
Activities of daily living (Modified Barthel Index) 0-100, change score Mean (95% CI)	NR (NR to NR)	23.87 (20.02 to 27.73)	NR (NR to NR)	22.98 (19.28 to 26.67)

1 Arm function (FMA UE) - Polarity - Higher values are better
2 Arm strength (Motricity Index) - Polarity - Higher values are better
3 Person/participant generic health related quality of life (SF-36 MCS) - Polarity - Higher values are better
4 Person/participant generic health related quality of life (SF-36 PCS) - Polarity - Higher values are better
5 Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better

6 ***dichotomous outcomes***

Outcome	robotic group, Baseline, N = 123	robotic group, 6 week, N = 123	conventional group, Baseline, N = 124	conventional group, 6 week, N = 124
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 32 ; % = 26	n = 0 ; % = 0	n = 25 ; % = 20

7 Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armstrength(MotricityIndex)-MeanNineFivePercentCI-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armfunction(FMAUE)-MeanNineFivePercentCI-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanNineFivePercentCI-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armstrength(MotricityIndex)-MeanSD-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36MCS)-MeanNineFivePercentCI-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and bias in the measurement of outcome missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36PCS)-MeanNineFivePercentCI-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and bias in the measurement of outcome missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36MCS)-MeanSD-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and bias in the measurement of outcome missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36PCS)-MeanSD-robotic group-conventional group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to adhering to intervention and bias in the measurement of outcome missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Aprile, 2021

Bibliographic Reference	Aprile, I.; Germanotta, M.; Cruciani, A.; Pecchioli, C.; Loreti, S.; Papadopoulou, D.; Montesano, A.; Galeri, S.; Diverio, M.; Falsini, C.; Speranza, G.; Langone, E.; Carrozza, M. C.; Cecchi, F.; Poststroke shoulder pain in subacute patients and its correlation with upper limb recovery after robotic or conventional treatment: A secondary analysis of a multicenter randomized controlled trial; International Journal of Stroke; 2021; vol. 16 (no. 4); 396-405

Study details

Secondary publication of another included study- see primary study for details	Aprile, Irene MD, PhD; Germanotta, Marco PhD; Cruciani, Arianna PT; Loreti, Simona MD; Pecchioli, Cristiano BS; Cecchi, Francesca MD; Montesano, Angelo MD; Galeri, Silvia MD; Diverio, Manuela MD; Falsini, Catuscia MD; Speranza, Gabriele MD; Langone, Emanuele MD; Papadopoulou, Dionysia PT; Padua, Luca MD, PhD; Carrozza, Maria Chiara PhD; for the FDG Robotic Rehabilitation Group Upper Limb Robotic Rehabilitation After Stroke: A Multicenter, Randomized Clinical Trial, Journal of Neurologic Physical Therapy: January 2020 - Volume 44 - Issue 1 - p 3-14doi: 10.1097/NPT.0000000000000295
Other publications associated with this study included in review	Padua L, Imbimbo I, Aprile I, Loreti C, Germanotta M, Coraci D, Piccinini G, Pazzaglia C, Santilli C, Cruciani A, Carrozza MC; FDG Robotic Rehabilitation Group†. Cognitive reserve as a useful variable to address robotic or conventional upper limb rehabilitation treatment after stroke: a multicentre study of the Fondazione Don Carlo Gnocchi. Eur J Neurol. 2020 Feb;27(2):392-398. doi: 10.1111/ene.14090. Epub 2019 Oct 18. PMID: 31536677.

Bishop, 2014

Bibliographic Reference	Bishop, L.; Stein, J.; Schoenherr, G.; Chen, C.; Nilsen, D.; Beer, R.; Robot-assisted hand exercise compared with conventional exercise therapy after ischemic stroke: a pilot study; Neurorehabilitation and Neural Repair; 2014; vol. 28 (no. 9); 919

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Helbok R. Robot-assisted hand training (AMADEO) compared with conventional physiotherapy techniques in chronic ischemic stroke patients: a pilot study. *Neurologie und Rehabilitation*. 6. Innsbruck, Austria: Hippocampus Verlag, 2010:281.
Trial name / registration number	No additional information.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information.

Study arms

Robot-assisted arm therapy (N = 16)
Robot therapy with the Amadeo Hand robot three times per week for eight weeks, for 60 minutes. Concomitant therapy: No additional information.

Any other intervention (N = 15)
Standard arm therapy for three times per week for eight weeks, for 60 minutes. Concomitant therapy: No additional information.

Outcomes

Study timepoints

- Baseline
- 8 week (Post-intervention)

Continuous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 16	Robot-assisted arm therapy, 8 week, N = 14	Any other intervention, Baseline, N = 15	Any other intervention, 8 week, N = 14
Activities of daily living (barthel index) Scale range: 0-100. Change scores. Mean (SD)	NR (NR)	-0.36 (12.3)	NR (NR)	6.78 (19.1)
Arm function (Fugl-meyer Upper Extremity) Scale range: 0-66. Change scores. Mean (SD)	NR (NR)	2.1 (16.3)	NR (NR)	5.9 (13.7)
Arm muscle strength (Motor Activity Log) Scale range: 0-5. Change scores. Mean (SD)	NR (NR)	0.84 (5.3)	NR (NR)	1.63 (7.8)

Activities of daily living (barthel index) - Polarity - Higher values are better

Arm function (Fugl-meyer Upper Extremity) - Polarity - Higher values are better
Arm muscle strength (Motor Activity Log) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot-assisted arm therapy, Baseline, N = 16	Robot-assisted arm therapy, 8 week, N = 16	Any other intervention, Baseline, N = 15	Any other intervention, 8 week, N = 15
Withdrawal for any reason No additional information. No of events	n = NA ; % = NA	n = 2 ; % = 13	n = NA ; % = NA	n = 1 ; % = 7

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(barthelindex)-MeanSD-Robot-assisted arm therapy-Any other intervention-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-meyerUpperExtremity)-MeanSD-Robot-assisted arm therapy-Any other intervention-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotorActivityLog)-MeanSD-Robot-assisted arm therapy-Any other intervention-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Any other intervention-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Brokaw, 2014

Bibliographic Reference	Brokaw, Elizabeth B.; Nichols, Diane; Holley, Rahsaan J.; Lum, Peter S.; Robotic therapy provides a stimulus for upper limb motor recovery after stroke that is complementary to and distinct from conventional therapy; Neurorehabilitation and neural repair; 2014; vol. 28 (no. 4); 367-376

1 **Study details**

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	Not stated/unclear
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

2

Study arms

Robotic training (N = 7)
group AB: 12 hours of robotic training within a month (A) and 12 hours of conventional therapy within a month (b), separated by a month of wash-out period.

Conventional therapy (N = 5)
group BA: 12 hours of conventional therapy within a month (b), and 12 hours of robotic training within a month (A) separated by a month of wash-out period.

Outcomes

Study timepoints
- Baseline
- 1 month (Post-intervention)

Continuous outcomes

Outcome	Robotic training, Baseline, N = 7	Robotic training, 1 month, N = 7	Conventional therapy, Baseline, N = 5	Conventional therapy, 1 month, N = 5
Arm function (Fugl-Meyer assessment) (0-66) Mean (SD)	NR (NR)	1.8 (2)	NR (NR)	1.2 (2)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Change scores. Also reports ARAT and BBT. Values taken from graph.

Dichotomous outcome

Outcome	Robotic training, Baseline, N = 7	Robotic training, 1 month, N = 7	Conventional therapy, Baseline, N = 5	Conventional therapy, 1 month, N = 5
Withdrawal for any reason 2 lost to follow-up: 1 due to transportation, 1 unknown. No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 2 ; % = 40

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robotic training-Conventional therapy-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robotic training-Conventional therapy-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Budhota, 2021

Bibliographic Reference	Budhota, A.; Chua, K. S. G.; Hussain, A.; Kager, S.; Cherpin, A.; Contu, S.; Vishwanath, D.; Kuah, C. W. K.; Ng, C. Y.; Yam, L. H. L.; Loh, Y. J.; Rajeswaran, D. K.; Xiang, L.; Burdet, E.; Campolo, D.; Robotic Assisted Upper Limb Training Post Stroke: A Randomized Control Trial Using Combinatory Approach Toward Reducing Workforce Demands; Frontiers in neurology [electronic resource].; 2021; vol. 12; 622014

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	NCT02188628
Study type	Randomised controlled trial (RCT)
Study location	Singapore
Study setting	The study was conducted at the outpatient clinic of the Tan Tock Seng Hospital, Centre for Advanced Rehabilitation Therapeutics (TTSH-CART), Singapore, a tertiary rehabilitation center with direct links to a national stroke center.
Study dates	Conducted over two years from 1st April 2016 to 31st April 2018.
Sources of funding	This work was supported by the National Medical Research Council (NMRC, NMRCB2b0006c) Singapore and the H-Man project (NMRC/BnB/0006b/2013), Ministry of Health, Singapore; Ageing Research Institute for Society and Education (ARISE), Singapore: M4082063 and Interdisciplinary Graduate School, Nanyang Technological University, Singapore. Grant support duration: 2013–2018.

Inclusion criteria	Inclusion criteria for this study were: a first-ever stroke diagnosed by stroke neurologists or neurosurgeons and brain imaging, age between 21 and 85 years, time since stroke within 3–24 months, predominant arm motor function deficits with baseline FMA score between 20 and 50 or presence of motor ataxia, and the ability to understand instructions and give informed consent.
Exclusion criteria	Exclusion criteria for this study were: uncontrolled medical illnesses, pregnancy, life expectancy <6 months, inability to sit upright with support for <90 min due to postural hypotension or pressure intolerance, arm related contraindications to robot aided therapy such as shoulder pain [Visual Analog Scale (55), VAS > 4/10], spasticity [Modified Ashworth Scale (56), MAS > 2], severe sensory and visual impairments, hemi spatial neglect assessed using the line bisection test, and screening Mini-Mental State Examination score, MMSE <27/30.
Recruitment / selection of participants	Participants were consecutively identified through an inpatient stroke rehabilitation standing database and their involvement lasted a total of 24 weeks. Majority of subjects had completed inpatient rehabilitation at the centre's rehabilitation hospital
Intervention(s)	Robotic Therapy (RT) n=22 The group underwent a 60 min robotic therapy session, minimally supervised by occupational therapists and bio-engineers, followed by a 30 min 1:1 conventional therapy session. During the robotic therapy, the subjects performed a point-to-point reaching task (in different shape patterns) with H-Man, which incorporated a performance based adaptive controller. The controller adjusts the interaction dynamics trial-by-trial based on an online estimation of patients task performance during a point to point reaching task, ranging from performance enhancement to performance degradation. The conventional therapy included passive mobilization and active-assisted approaches based on neuro-developmental techniques to enhance normal movement patterns, repetitive tasks, specific training for functional reach training and the use of upper limb inclined board and motorized arm bike. Both of the groups received the same number of training sessions (*n* = 18) of 90 min each, three times a week and over a span of 6 weeks. Concomitant treatment: 30 min 1:1 conventional therapy session.
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised 'minimally supervised'
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	NR
Comparator	Conventional Therapy (CT) n=22 The group received 90 min of 1:1 conventional therapy from a trained occupational therapist. The conventional therapy included passive mobilization and active-assisted approaches based on neuro-developmental techniques to enhance normal movement patterns, repetitive tasks, specific training for functional reach training and the use of upper limb inclined board and motorized arm bike. Both of the groups received the same number of training sessions (*n* = 18) of 90 min each, three times a week and over a span of 6 weeks

	Concomitant treatment: none reported.
Number of participants	44
Duration of follow-up	24 weeks
Indirectness	N/A

Study arms

Robotic therapy (N = 22)
18 training sessions of 90 min each, three times a week and over a span of 6 weeks.

Conventional therapy (N = 22)
18 training sessions of 90 min each, three times a week and over a span of 6 weeks.

Characteristics

Study-level characteristics

Characteristic	**Study (N = 44)**
% Female No of events	n = 19 ; % = 43

Arm-level characteristics

Characteristic	Robotic therapy (N = 22)	Conventional therapy (N = 22)
Mean age (SD) Mean (SD)	56.32 (10.37)	54.59 (10.92)
Time after stroke Days Median (IQR)	458 (451.3 to *empty data*)	390 (327.5 to *empty data*)

Outcomes

Study timepoints

- Baseline
- 6 week (Post-intervention)
- 24 week (Post-intervention)

Dichotomous outcome

Outcome	Robotic therapy, Baseline, N = 22	Robotic therapy, 6 week, N = 22	Robotic therapy, 24 week, N = 22	Conventional therapy, Baseline, N = 22	Conventional therapy, 6 week, N = 22	Conventional therapy, 24 week, N = 22
Withdrawal for any reason The week 24 outcome assessment in one participant could not be performed due to a wrist injury related to a fall	n = NA ; % = NA	n = 0 ; % = 0	n = 1 ; % = 5	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0

Outcome	Robotic therapy, Baseline, N = 22	Robotic therapy, 6 week, N = 22	Robotic therapy, 24 week, N = 22	Conventional therapy, Baseline, N = 22	Conventional therapy, 6 week, N = 22	Conventional therapy, 24 week, N = 22
during the follow-up phase that was unrelated to training. No of events						
Adverse events Narrative statement: 'there were no training related adverse side effects or drop outs up to week 6 of the study'. No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

Continuous outcomes

Outcome	Robotic therapy, Baseline, N = 22	Robotic therapy, 6 week, N = 22	Robotic therapy, 24 week, N = 21	Conventional therapy, Baseline, N = 22	Conventional therapy, 6 week, N = 22	Conventional therapy, 24 week, N = 22
Arm function (Fugl-Meyer assessment) Final values. Scale range 0-66. Mean (SD)	40.23 (9.3)	44.64 (9.77)	45.33 (11.43)	35.86 (11.65)	38.86 (11.69)	40.36 (11.57)
Arm muscle strength (grip strength) Final values. Mean (SD)	7.49 (3.22)	9.41 (4.84)	10.86 (6.28)	6.72 (4.12)	7.81 (3.7)	8.94 (4.01)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm muscle strength (grip strength) - Polarity - Higher values are better
Also reports ARAT.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armmusclestrength(gripstrength)-MeanSD-Robotic therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robotic therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robotic therapy-Conventional therapy-t24

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Armmusclestrength(gripstrength)-MeanSD-Robotic therapy-Conventional therapy-t24

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Armfunction(FuglMeyerassessment)-MeanSD-Robotic therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerassessment)-MeanSD-Robotic therapy-Conventional therapy-t24

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcome-Adverseevents-NoOfEvents-Robotic therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Adverseevents-NoOfEvents-Robotic therapy-Conventional therapy-t24

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Burgar, 1999

Bibliographic Reference	Burgar, C. G.; Lum, P. S.; Shor, M.; Van der Loos, H. F. M.; Rehabilitation of upper limb dysfunction in chronic hemiplegia: robot-assisted movements vs. conventional therapy; Arch Phys Med Rehabil; 1999; vol. 80 (no. 9); 1121

Study details

Secondary publication of another included study- see primary study for details	Lum PS, Burgar CG, Shor PC, Majmundar M, Van der Loos M. Robot-assisted movement training compared with conventional therapy techniques for the rehabilitation of upper-limb motor function after stroke. *Archives of Physical Medicine and Rehabilitation* 2002;83(7):952-9.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Burgar C, Lum P, Shor P, Van der Loos H. Development of robots for rehabilitation therapy: the Palo Alto VA/Stanford experience. *Journal of Rehabilitation Research and Development* 2000;37(6):663-73.

Burgar, 2011

Bibliographic Reference	Burgar, Charles G.; Lum, Peter S.; Scremin, A. M.; Garber, Susan L.; Van der Loos, H. F.; Kenney, Deborah; Shor, Peggy; Robot-assisted upper-limb therapy in acute rehabilitation setting following stroke: Department of Veterans Affairs multisite clinical trial; J Rehabil Res Dev; 2011; vol. 48 (no. 4); 445-458

Study details

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Mixed Mean 27 points FIM upper limb.

Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months) mean 11 days.
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot therapy (N = 36)
15 x1 hour therapy sessions over a 3 week period (1 robot group received 30 1 hour therapy sessions over 3 week period).

Control (N = 18)
15 x1 hour therapy sessions over a 3 week period

Outcomes

Study timepoints

- Baseline
- 3 week (Post-intervention)
- 6 month (Post-intervention)

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 36	Robot therapy, 3 week, N = 36	Robot therapy, 6 month, N = 25	Control, Baseline, N = 18	Control, 3 week, N = 18	Control, 6 month, N = 12
Arm function (Fugi-Meyer) (0-66) Change score Mean (SE)	23 (3.23)	10.6 (1.93)	23.1 (3.88)	24.2 (4.8)	14 (15.3)	15.3 (17)
Activities of daily living(FIM upper limb) (0-63) Change score Mean (SE)	28.2 (1.59)	19.6 (1.42)	25.7 (2.12)	26.9 (2)	15.9 (1.5)	26.8 (3.1)
Arm muscle strength (motor power) (0-70) Change score Mean (SE)	24.9 (1.76)	14.9 (1.86)	22.3 (2.72)	24.9 (4.2)	15.4 (3.7)	24.4 (4.8)
Spasticity (Ashworth MAS) (max 5 points) Change score	0.38 (0.063)	0.09 (0.02)	0.4 (0.1)	0.33 (0.08)	0.11 (0.1)	0.16 (0.15)

Outcome	Robot therapy, Baseline, N = 36	Robot therapy, 3 week, N = 36	Robot therapy, 6 month, N = 25	Control, Baseline, N = 18	Control, 3 week, N = 18	Control, 6 month, N = 12
Mean (SE)						

Arm function (Fugi-Meyer) - Polarity - Higher values are better
Activities of daily living(FIM upper limb) - Polarity - Higher values are better
Arm muscle strength (motor power) - Polarity - Higher values are better
Spasticity (Ashworth MAS) - Polarity - Lower values are better
Change scores. Robot groups combined for analysis. FM values (mean plus SE): at baseline, Robot-Lo: 26.7 (5.0), Robot-Hi: 19.0 (3.7); at post-intervention, Robot-Lo: 6.8 (1.9), Robot-Hi: 14.4 (3.6); at 6 month follow-up: Robot-Lo: 15.9 (3.5), Robot-Hi: 23.6 (5.8). FIM values (mean plus SE): at baseline, Robot-Lo: 28.4 (2.6), Robot-Hi: 27.9 (1.7); at post-intervention, Robot-Lo: 17.7 (1.9) , Robot-Hi: 21.5 (2.1) at 6 month follow-up: Robot-Lo: 24.2 (2.9), Robot-Hi: 27.5 (3.0). Motor Power values (mean plus SE): at baseline, Robot-Lo: 27.9 (4.8), Robot-Hi: 21.5 (4.2); at post-intervention, Robot-Lo: 13.7 (2.3) , Robot-Hi: 16.0 (3.0) at 6 month follow-up: Robot-Lo: 18.0 (3.3), Robot-Hi: 27.8 (4.0). Ashworth values (mean plus SE): at baseline, Robot-Lo: 0.44 (0.10), Robot-Hi: 0.31 (0.08); at post-intervention, Robot-Lo: 0.00 (0.06) , Robot-Hi: 0.19 (0.09) at 6 month follow-up: Robot-Lo: 0.02 (0.14), Robot-Hi: 0.83 (0.25). Also reports WMFT

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 36	Robot therapy, 3 week, N = 36	Robot therapy, 6 month, N = 36	Control, Baseline, N = 18	Control, 3 week, N = 18	Control, 6 month, N = 18
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugi-Meyer)-MeanSE-Robot therapy-Control-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugi-Meyer)-MeanSE-Robot therapy-Control-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(FIMupperlimb)-MeanSE-Robot therapy-Control-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(FIMupperlimb)-MeanSE-Robot therapy-Control-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(motorpower)-MeanSE-Robot therapy-Control-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(motorpower)-MeanSE-Robot therapy-Control-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSE-Robot therapy-Control-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSE-Robot therapy-Control-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot therapy-Control-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Burgar, 2000

Bibliographic Reference	Burgar, Charles G.; Lum, Peter S.; Shor, Peggy C.; Van der Loos, H. F. Machiel; Development of robots for rehabilitation therapy: The Palo Alto VA/Stanford experience; Journal of rehabilitation research and development; 2000; vol. 37 (no. 6); 663-674

Study details

Secondary publication of another included study- see primary study for details	Lum PS, Burgar CG, Shor PC, Majmundar M, Van der Loos M. Robot-assisted movement training compared with conventional therapy techniques for the rehabilitation of upper-limb motor function after stroke. *Archives of Physical Medicine and Rehabilitation* 2002;83(7):952-9.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Burgar CG, Lum PS, Shor M, Loos HFM. Rehabilitation of upper limb dysfunction in chronic hemiplegia: robot-assisted movement versus conventional therapy. *Archives of Physical Medicine and Rehabilitation* 1999;80:1121.

Calabro, 2019

Bibliographic Reference	Calabro, R. S.; Accorinti, M.; Porcari, B.; Carioti, L.; Ciatto, L.; Billeri, L.; Andronaco, V. A.; Galletti, F.; Filoni, S.; Naro, A.; Does hand robotic rehabilitation improve motor function by rebalancing interhemispheric connectivity after chronic stroke? Encouraging data from a randomised-clinical-trial; Clinical Neurophysiology; 2019; vol. 130 (no. 5); 767-780

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR

Trial name / registration number	NCT03292276
Study location	Italy
Study setting	In-patient, at the Neuro-robotic Rehabilitation Unit of the IRCCS Centro Neurolesi Bonino Pulejo.
Study dates	Between January and February 2018.
Sources of funding	No funding.
Inclusion criteria	Patients were rated as eligible according to the following criteria: (i) age ≤55 years; (ii) a first, single, ischemic, supra-tentorial, chronic-stage stroke at least 6 months after the event, confirmed by T1-weighted structural whole brain Magnetic Resonance Imaging, performed at the scoring of chronic upper limb function; (iii) a Muscle Research Council score ≤3 concerning shoulder abduction –deltoid– elbow flexion –biceps brachii– and wrist flexion –wrist flexors); (iv) a Mini–Mental State Examination score >24 (that is, the patient was able to follow verbal instructions); (v) a Modified Ashworth Scale score of the hand muscles ≤2; (vi) no prior history of severe bone or joint disease; and (vii) no prior history of concomitant neurodegenerative diseases or brain surgery.
Exclusion criteria	Not reported.
Recruitment / selection of participants	Not reported (all were inpatients at the unit where the study was taking place).
Intervention(s)	AmadeoTM hand training (AHT) n=25 The patients in the AHT group underwent 40 individual conventional 3-hour physiotherapeutic training sessions, 5 days a week for 8 weeks (starting between 9:00 am and 11:00 am). The sessions were divided into 45 min of occupational therapy (daily living and reaching activities), 45 min of biomechanical training of both upper and lower limbs, 30 min of gait training, 30 min of speech therapy, and 30 min of rest period (distributed between the sessions) followed by 45 min of robot-assisted therapy of the affected limb using AmadeoTM. Each hand training session consisted of random order exercises: (i) 15 min of continuous passive motion; (ii) 25 min of assisted therapy (movements were robot-assisted according to individual performance); and (iii) 5 min of rest period between the two sessions. The movement execution was standardised: the fingers were first extended for 1 s and then flexed and extended continuously for 5 s at a frequency of 0.2 Hz. The entire flexion–extension cycle lasted 6 s. The device guidance force (DGF), during assisted therapy, was adapted to each patient's progress. Specifically, the machine detected the patient's finger movements and intervened to drive and/or complete them within the span of 6 s. The amount of required assistance was recorded by the device itself. During the

	session, an AmadeoTM–trained physiotherapist supervised each patient's intervention adherence. Distinct video–acoustic cues signalled the patient when each movement cycle began and ended (in the passive condition) and when to move (in the assisted condition). Concomitant treatment: The patients were asked not to undertake other physiotherapy treatments during the 8-week training period.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	Not reported.

Comparator	Conventional hand training n=25 The patients in the CHT group also underwent 40 individual conventional 3-hour physiotherapy sessions, 5 days a week for an 8–week period, between 9:00 am and 11:00 am. This training had the same characteristics described for the AHT group. Each session was then followed by a 45 min conventional hand therapy session carried out by an occupational therapist, who both performed and assisted the patient in the execution of finger movements, reproducing the same experimental conditions of the AHT group (upper limb position and constrainment, movement execution, flexion–extension finger movements, movement frequency and velocity, degree of assistance, and video–acoustic cueing). The similar setup was necessary to avoid biasing effects on sensory processing due to differences in the restraint of the wrist between AHT and CHT. Muscle synergies are affected by robot-dependent mechanical constraints and forces, thus affecting the sensorimotor system. Concomitant treatment: The patients were asked not to undertake other physiotherapy treatments during the 8-week training period.
Number of participants	50
Duration of follow-up	8 weeks
Indirectness	None.
Additional comments	All of the randomized patients were included in the primary analysis, as an intent-to-treat approach was adopted.

Study arms

Amadeo hand training (N = 25)

40 hand training sessions of 45min each, 5 times a week, for 8 consecutive weeks.

Conventional hand training (N = 25)
40 hand training sessions of 45min each, 5 times a week, for 8 consecutive weeks.

Characteristics

Arm-level characteristics

Characteristic	Amadeo hand training (N = 25)	Conventional hand training (N = 25)
% Female No of events	n = 14 ; % = 56	n = 11 ; % = 44
Mean age (SD) Mean (SD)	65 (3)	64 (3)
Time after stroke months Mean (SD)	10 (2)	10 (2)

Outcomes

Study timepoints

- Baseline
- 8 week (Post-intervention)

Dichotomous outcomes

Outcome	Amadeo hand training , Baseline, N = 25	Amadeo hand training , 8 week, N = 25	Conventional hand training, Baseline, N = 25	Conventional hand training, 8 week, N = 25
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0
Adverse events Narrative report of no adverse events in either group No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Amadeo hand training , Baseline, N = 25	Amadeo hand training , 8 week, N = 25	Conventional hand training, Baseline, N = 25	Conventional hand training, 8 week, N = 25
Arm function (Fugl-meyer Upper Extremity) Final values. Scale range 0-66 Mean (SD)	29 (3)	36 (4)	30 (3)	34 (4)

Arm function (Fugl-meyer Upper Extremity) - Polarity - Higher values are better

Also reports 9 Hole Peg Test, Motor Evoked Potential, Short latency afferent inhibition and repetitive paired associative stimulation.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Function(Fugl-meyerUpperExtremity)-MeanSD-Amadeo hand training -Conventional hand training-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Amadeo hand training -Conventional hand training-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Amadeo hand training -Conventional hand training-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Carpinella, 2020

Bibliographic Reference	Carpinella, I.; Lencioni, T.; Bowman, T.; Bertoni, R.; Turolla, A.; Ferrarin, M.; Jonsdottir, J.; Effects of robot therapy on upper body kinematics and arm function in persons post stroke: a pilot randomized controlled trial; Journal of Neuroengineering & Rehabilitation; 2020; vol. 17 (no. 1); 10

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	Lencioni T, Jonsdottir J, Ferrarin M, Marzegan A, Bowman T, Turolla A, et al. Effects of planar robotic rehabilitation on muscle synergies of the upper limbs in post-stroke subjects. Gait & Posture. 2016;49:S4.
Trial name / registration number	NCT03530358
Study location	Italy
Study setting	2 stroke rehabilitation hospitals
Study dates	March 2015 to November 2017.
Sources of funding	This work was supported by the Italian Ministry of Health (Ricerca Corrente and Ricerca Finalizzata: grant no. GR-2011-02348942).
Inclusion criteria	Inclusion criteria were: first ischemic or hemorrhagic stroke, a score between 1 and 3 at the upper limb sub-item on the Italian version of the National Institute of Health stroke scale (IT - NIHSS), a score higher than 6 out of 66 points on the Fugl-Meyer Motor Assessment of Upper Extremity (FM-UE) scale
Exclusion criteria	Exclusion criteria were: presence of a moderate cognitive decline defined as a Mini Mental State Examination score < 20 points, evidence of severe verbal comprehension deficit, apraxia and/or visuospatial neglect as assessed through neurological examination, report in the patient's clinical history or evidence from the neurological examination of behavioral disturbances (i.e. delusions, aggressiveness and severe apathy/depression) that could affect compliance with the rehabilitation programs, presence of non-stabilized fractures, presence of traumatic brain injury, presence of drug resistant epilepsy.

Recruitment / selection of participants	A consecutive sample of 116 adults post-stroke from the Neurorehabilitation Department of IRCCS Don Carlo Gnocchi Foundation (Milan, Italy) was assessed for eligibility from March 2015 to November 2017.
Intervention(s)	Participants allocated to the R_Group received a robot based training using a planar robotic manipulandum (Braccio di Ferro, Celin s.r.l., Italy) aimed at practicing shoulder and elbow movements in the horizontal plane. Subjects were seated on a chair while grasping the handle of the robot with the paretic hand. A large computer screen was used to display the current position of the hand and the target represented by circles with a diameter of 3 cm (Fig. 2a). The task consisted of repeated centre-out reaching movements and back, from a central target to a peripheral target randomly presented in one of five positions arranged on a semicircle with a 20 cm radius. The robotic system enabled the execution of reaching movements in two force modes, assist-as-needed and resistive. At the beginning of the following sessions, the physiotherapist analysed the summary report (see the example of Fig. 2b) showing the values of three robot-based indexes (i.e. maximum assistive force, reaching duration and number of movements units) related to the first and the last sessions performed. If the maximum assistive force generated by the robot during the previous session was greater than 1. N, the current session was still executed in the assist-as needed mode, otherwise the physiotherapist changed the exercise to the resistive mode, setting the rigidity K to the minimum value of 5 N/m. If the participant was unable to reach at least five targets within 10 s each, or if he/she had arm pain, the physiotherapist reloaded the exercise in the assist-as-needed mode, otherwise the session was executed in the resistive mode. The number of reaching movements executed during each 45-min session was between 240 in most impaired participants and 500 in less impaired participants. Trunk was not constrained during the training and the training did not directly involve intrinsic movements of the hand. Concomitant therapy -Participants in both the Robot and Control groups received a rehabilitation treatment for the affected upper limb consisting of 20 sessions of 45 min each, 5 times a week by trained physiotherapists.
Subgroup 1: Severity	Mild (or NIHSS 1-5)
Subgroup 2: Time after stroke at the start of the trial	Mixed
Subgroup 3: Region of upper limb trained	Proximal limb

Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	Participants allocated to the C_Group underwent usual care arm-specific physiotherapy that typically consisted of passive and active mobilization of scapula, shoulder, elbow and wrist, followed by task-oriented exercises that incorporated single or multi-joint movements aimed at improving arm functionality. Task-oriented activities were tailored to participants' abilities, and included hand to mouth movements, reaching towards and grasping objects, moving objects from one location to another. Participants that were not able to grasp would aim at moving towards objects in various trajectories, pushing them from one setting to another. Progression was obtained by increasing range of motion, number of repetitions and muscular coordination requests. A paper published by Kimberley et al. estimated that a typical number of movements executed in a usual care rehabilitation session, such as that carried out by the C_ Group, was around 40–45 repetitions.
Number of participants	40
Duration of follow-up	4 weeks end of intervention
Indirectness	NR
Additional comments	NR

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Study arms

robot therapy (N = 20)

Conventional therapy (N = 20)

Characteristics

Study-level characteristics

Characteristic	Study (N = 40)
Ethnicity Nominal	NR
Comorbidities Nominal	NR

Arm-level characteristics

Characteristic	robot therapy (N = 20)	Conventional therapy (N = 20)
% Female Nominal	47	47
Mean age (SD) Median (IQR)	67 (58 to 70)	59 (46 to 69)

Characteristic	robot therapy (N = 20)	Conventional therapy (N = 20)
Severity Nominal	NR	NR
Time after stroke Median (IQR)	7 (1.7 to 11.9)	5.3 (1.9 to 89.6)

Outcomes

Study timepoints

- Baseline
- 4 week

Continuous outcomes

Outcome	robot therapy, Baseline, N = 20	robot therapy, 4 week, N = 19	Conventional therapy, Baseline, N = 20	Conventional therapy, 4 week, N = 19
Arm function (Fugl Meyer UE) 0-66, change scores Mean (SD)	35.3 (18.6)	7 (6.3)	28.1 (18.5)	6.2 (9.3)
Activties of daily living (functional independence measure) 18-126, change score Mean (SD)	99.9 (14.1)	9.3 (5.8)	92 (16.7)	8.7 (11.6)

Arm function (Fugl Meyer UE) - Polarity - Higher values are better

Activties of daily living (functional independence measure) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	robot therapy, Baseline, N = 20	robot therapy, 4 week, N = 20	Conventional therapy, Baseline, N = 20	Conventional therapy, 4 week, N = 20
Withdrawal for any reason Two persons discontinued the training, one for medical complications unrelated to the study, and one for early discharge from the hospital. No of events	n = 0 ; % = 0	n = 1 ; % = 5	n = 0 ; % = 0	n = 1 ; % = 5

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activtiesofdailyliving(functionalindependencemeasure)-MeanSD-robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Chen, 2022

Bibliographic Reference	Chen, Y. W.; Chiang, W. C.; Chang, C. L.; Lo, S. M.; Wu, C. Y.; Comparative effects of EMG-driven robot-assisted therapy versus task-oriented training on motor and daily function in patients with stroke: a randomized cross-over trial; Journal of Neuroengineering & Rehabilitation; 2022; vol. 19 (no. 1); 6

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with	No additional information.

this study included in review	
Trial name / registration number	Clinicaltrials.gov = NCT03624153
Study type	Randomised controlled trial (RCT)
Study location	Taiwan
Study setting	Outpatient follow up
Study dates	No additional information
Sources of funding	This study was supported by Chang Gung Memorial Hospital (BMRP553, CMRPD1I0033), the Ministry of Science and Technology (MOST 109-2314-B-192-027-MY3) and Healthy Aging Research Center, Chang Gung University from the Featured Areas Research Center Program within the Framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan (EMRPD1L0411).
Inclusion criteria	Unilateral stroke at least 3 months prior to study enrolment; Fugl-Meyer Assessment for Upper Extremity score <60; without excessive spasticity in any of the upper extremity joint (modified Ashworth scale no more than 3); Mini Mental State Exam score >24, indicating no serious cognitive impairment; between the ages of 20 and 75 years.
Exclusion criteria	Histories of other neurological diseases such as dementia and peripheral polyneuropathy; difficulties in following and understanding instructions such as global aphasia; enroll in other rehabilitation or drug studies simultaneously; receiving botulinum toxin injections within 3 months.
Recruitment / selection of participants	No additional information.
Intervention(s)	Robot-assisted arm training N=16 Hand of Hope robotic hand system which had training modes including: continuous passive motion, EMG biofeedback - trigger and go, EMG biofeedback - trigger and maintain and interactive passive games. 12 sessions of robot-assisted intervention first, followed by a 1-month washout period, then 12 sessions of task-oriented interventions (only the follow up at the initial 12 sessions will be used in this data extraction). Each sessions consisted of 20-minutes continuous passive motion, 20-minutes active motion practice and 30-minutes interactive gaming practice.

	Concomitant therapy: No additional information.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.
Comparator	Usual care N=15 Task-oriented interventions. 12 sessions. After which they had a 1-month washout period and then participated in 12 sessions of robot assisted arm training (only the follow up at the initial 12 sessions will be used in this data extraction).

	Included 20-minutes warm up including range of motion exercise and strengthening exercise followed by 50-minutes task-oriented training for activities of daily living under the supervision of a senior occupational therapist. Concomitant therapy: No additional information.
Number of participants	31
Duration of follow-up	4 weeks (after the first phase of treatment will be the follow up period used in this review as stated in the protocol)
Indirectness	No additional information
Additional comments	No additional information

Study arms

Robot-assisted arm training (N = 16)
Hand of Hope robotic hand system which had training modes including: continuous passive motion, EMG biofeedback - trigger and go, EMG biofeedback - trigger and maintain and interactive passive games. 12 sessions of robot-assisted intervention first, followed by a 1-month washout period, then 12 sessions (3 sessions per week for 4 consecutive weeks) of task-oriented interventions (only the follow up at the initial 12 sessions will be used in this data extraction). Each sessions consisted of 20-minutes continuous passive motion, 20-minutes active motion practice and 30-minutes interactive gaming practice. Concomitant therapy: No additional information.

Usual care (N = 15)
Task-oriented interventions. 12 sessions (3 sessions per week for 4 consecutive weeks). After which they had a 1-month washout period and then participated in 12 sessions of robot assisted arm training (only the follow up at the initial 12 sessions will be used in this data extraction). Included 20-minutes warm up including range of motion exercise and strengthening exercise followed by 50-minutes task-oriented training for activities of daily living under the supervision of a senior occupational therapist. Concomitant therapy: No additional information.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 16)	Usual care (N = 15)
% Female Sample size	n = 4 ; % = 29	n = 1 ; % = 10
Mean age (SD) (years) Mean (SD)	54.58 (10.98)	64.98 (8.22)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (Months) Mean (SD)	37.07 (34.39)	59.8 (43.34)

Outcomes

Study timepoints

- Baseline

- 4 week (Post-intervention)

Continuous outcome

Outcome	Robot-assisted arm training, Baseline, N = 16	Robot-assisted arm training, 4 week, N = 14	Usual care, Baseline, N = 15	Usual care, 4 week, N = 10
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Final values. Mean (SD)	33 (8.53)	35.64 (9.3)	36.4 (10.1)	38.8 (10.32)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot-assisted arm training, Baseline, N = 16	Robot-assisted arm training, 4 week, N = 16	Usual care, Baseline, N = 15	Usual care, 4 week, N = 15
Withdrawal for any reason Intervention: 2 discontinued due to hospital discharge or personal issues. Control: 5 discontinued due to hospital discharge or personal issues. No of events	n = NA ; % = NA	n = 2 ; % = 13	n = NA ; % = NA	n = 5 ; % = 33

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Continuousoutcome-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm training-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Chen, 2021

Bibliographic Reference	Chen, Z. J.; Gu, M. H.; He, C.; Xiong, C. H.; Xu, J.; Huang, X. L.; Robot-Assisted Arm Training in Stroke Individuals With Unilateral Spatial Neglect: A Pilot Study; Frontiers in neurology [electronic resource].; 2021; vol. 12; 691444

Study details

Secondary publication of another included study- see primary study for details	NR

Other publications associated with this study included in review	NR
Trial name / registration number	ChiCTR1900026656
Study type	Randomised controlled trial (RCT)
Study location	China
Study setting	Department of Rehabilitation Medicine.
Study dates	Eligible patients were screened and enrolled from November 2018 until February 2021.
Sources of funding	This work received financial support for the research and publication of this article from National Natural Science Foundation of China (U 1913601 and No. 91648203).
Inclusion criteria	Inclusion Criteria included: (a) age 18–80; (b) clinical diagnosis of right hemisphere stroke (stroke onset from 2 weeks to 6 months); (c) Fugl-Meyer assessment of the upper extremity (FMA-UE) score 8–47; and (d) presence of USN defined by scoring of any item lesser than its cutoff value of the Behavioral Inattention Test conventional section (BIT-C).
Exclusion criteria	Exclusion criteria included: (a) not first-ever stroke; (b) other current significant impairments, for example, visual impairment, fixed contracture, shoulder subluxation; (c) diagnosis likely to interfere with rehabilitation or outcome assessments, for example, traumatic brain injury, epilepsy; and (d) unable to understand the intervention because of aphasia or other cognitive impairments
Recruitment / selection of participants	NR
Intervention(s)	Robot-assisted therapy (RAT) n=10 Participants in the RAT group received RAT (Armule®, Intelbot intelligent machine Co., Ltd, Wuhan, China) for remediating patients' neglect of contralateral space and affected upper extremity supervised by a therapist. When receiving robotic therapy, patients sat in a height-adjustable chair in front of the exoskeleton and looked at the computer monitor connected to the robotic device. Linkages between patients and the Armule were custom-fitted based on arm length and circumference. In addition, motion sensors were placed in the linkage cuffs of upper arm and forearm to detect the patient's

	movement intention. The robotic programs in this study were adapted to apply training for motor impairment and USN simultaneously by increasing left-side Armule sensorimotor interaction with the patients. Each training session consisted of 15-min passive mode and 30-min assist-as-need mode. During passive mode, the exoskeleton manipulated upper extremity with three-dimensional trajectory predetermined by the therapists according to patient-centered goals. Moreover, with the three-dimensional animation and voice prompts from the exoskeleton, patients were required to pay attention to the left side. During assist-as-need mode, patients practiced games and ADL training programs dedicated to the left side with audiovisual feedback, such as shooting targets, Whack-a-Mole, and cleaning windows. The Armule detected human-robot interaction forces and momentary position via the sensors in the linkage cuffs to estimate the participants' real-time movement intentions and performance for assistance when necessary. Training programs were progressed according to the performance of patients. The difficulty level for USN intervention was changed during robotic training by adjusting where the targets occurred on the computer screen, range of motion, and the robotic assistance. Besides, therapists could regulate the motion sensitivity of the exoskeleton to increase training difficulty for motor function. When the patient was not able to complete the tasks actively, the exoskeleton gave acoustic cues to patients and assistance supplied for the upper extremity supervised by the therapist. Interventions in both groups were delivered at the same frequency, intensity, and duration: 45 min daily, 5 days/week for 4 weeks. Concomitant treatment: conventional rehabilitation programs continued as usual for all the participants.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour

Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	NR
Comparator	Control group n=10 Participants in the group received general cognitive and occupational rehabilitation dedicated for unilateral spatial neglect, consisting of visual scanning therapy, passive range of movement of upper extremity and perceptual retraining integrated with task-specific activities. Interventions in both groups were delivered at the same frequency, intensity, and duration: 45 min daily, 5 days/week for 4 weeks. Concomitant treatment: conventional rehabilitation programs continued as usual for all the participants.
Number of participants	20
Duration of follow-up	4 weeks (immediately post-intervention).
Indirectness	N/A

Additional comments	NR

Study arms

Robot-assisted arm training (N = 10)
45 min daily, 5 days/week for 4 weeks.

Conventional therapy (N = 10)
45 min daily, 5 days/week for 4 weeks.

Characteristics

Study-level characteristics

Characteristic	**Study (N = 20)**
Mean age (SD) Mean (SD)	47.4 (8.47)
Ethnicity Not reported. Nominal	NR
Comorbidities Not reported Nominal	NR

Characteristic	Study (N = 20)
Severity Not reported Nominal	NR

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 10)	Conventional therapy (N = 10)
% Female No of events	n = 2 ; % = 20	n = 3 ; % = 30
Time after stroke (days) Mean (SD)	97.1 (84.37)	86.4 (61.92)

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention)

Dichotomous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 10	Robot-assisted arm training, 4 week, N = 10	Conventional therapy, Baseline, N = 10	Conventional therapy, 4 week, N = 10
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0
Adverse events narrative report of no adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 10	Robot-assisted arm training, 4 week, N = 10	Conventional therapy, Baseline, N = 10	Conventional therapy, 4 week, N = 10
Activities of daily living (Modified Barthel Index) Change scores. Scale range 0-100 Mean (SD)	45.6 (13.97)	28.9 (14.26)	50.4 (12.79)	21 (8.89)
Arm function (Fugl-Meyer assesment- upper extremity) Change scores. Scale range 0-66 Mean (SD)	23.1 (10.48)	13.6 (4.7)	20.5 (8.02)	9.5 (2.64)

Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better

Arm function (Fugl-Meyer assesment- upper extremity) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-Robot-assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot-assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassesment-upperextremity)-MeanSD-Robot-assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Chen, 2021

Bibliographic Reference	Chen, Z. J.; He, C.; Guo, F.; Xiong, C. H.; Huang, X. L.; Exoskeleton-Assisted Anthropomorphic Movement Training (EAMT) for Poststroke Upper Limb Rehabilitation: A Pilot Randomized Controlled Trial; Archives of Physical Medicine & Rehabilitation; 2021; vol. 102 (no. 11); 2074-2082

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	ChiCTR1900026656
Study type	Randomised controlled trial (RCT)

Study location	Unclear
Study setting	Unclear
Study dates	December 2018-May 2020
Sources of funding	Supported by the National Natural Science Foundation of China (grant nos. U 1913601, 91648203).
Inclusion criteria	The inclusion criteria included (1) age between 18-80 years; (2) a clinical diagnosis of stroke (cerebral infarction, primary intracerebral hemorrhage, subarachnoid hemorrhage) that occurred within the 6 months before enrollment; (3) motor impairment, defined as scoring between 8-47 on the Fugl-Meyer Assessment for Upper Extremity (FMA-UE); and (4) signed the written informed consent.
Exclusion criteria	The exclusion criteria were as follows: (1) >1 stroke (individuals with a previous transient ischemic attack could participate); (2) orthopedic conditions of the upper limb (eg, fixed contracture, shoulder subluxation, severe arthritis, or a recent fracture); (3) a diagnosis likely to interfere with the intervention or outcome measures (eg, traumatic brain injury, meningitis); (4) serious cognitive defects (Mini-Mental State Examination score <21) or aphasia preventing participation in the intervention; and (5) participation in any other clinical trial.
Recruitment / selection of participants	Recruited from the Department of Rehabilitation Medicine.
Intervention(s)	Exoskeleton-assisted anthropomorphic movement training n=10 The exoskeleton group received EAMT therapy that delivered task-specific training under anthropomorphic trajectories and postures. The participants sat in a height-adjustable chair in front of the exoskeleton, with their trunk strapped by a chest harness to prevent compensating movements. The upper limb remained in a neutral position initially and was fixed with Velcro straps. Linkages with the exoskeleton were adjustable to custom-fit each participant based on arm length and circumference. Each session consisted of 15-minute passive and 30-minute active-assistive exercises. During the passive mode, the individuals received mobilization under anthropomorphic movements predetermined by the therapists. During the active-assistive mode, the exoskeleton detected human−robot interaction forces and position via the sensors in the linkage cuffs to determine the participants' real-time movement intention and performance. Sensor information was synchronously projected to virtual games on the screen for EAMT training, such as shooting targets, Whack-a-Mole, drinking water, wiping their face, cleaning windows, and frying eggs.

	For both groups, therapy for the affected arm was delivered at the same frequency and duration: 45 minutes daily, 5 days per week, for 4 weeks. Concomitant treatment: all of the participants received routine multidisciplinary treatment, including medication and usual poststroke care.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	NR

Comparator	Conventional arm therapy n=10 The control group received conventional arm therapy. Each session was composed of passive stretching, active-assisted movement training, and functional task training for the upper extremities. Training programs that incorporated single or multi-joint movements were individualized and progressed according to the participants' abilities. The functional tasks included reaching, grasping, and transporting objects to attain the therapy goals. Concomitant treatment: all of the participants received routine multidisciplinary treatment, including medication and usual poststroke care.
Number of participants	20
Duration of follow-up	4 weeks (end of intervention)
Indirectness	None

Study arms

Exoskeleton-assisted anthropomorphic movement training (N = 10)
45 minutes daily, 5 days per week, for 4 weeks.

Conventional therapy (N = 10)
45 minutes daily, 5 days per week, for 4 weeks.

Characteristics

Arm-level characteristics

Characteristic	Exoskeleton-assisted anthropomorphic movement training (N = 10)	Conventional therapy (N = 10)
% Female No of events	n = 0 ; % = 0	n = 3 ; % = 30
Mean age (SD) Mean (SD)	47.1 (11.11)	54.9 (14.49)
Time after stroke Mean (SD)	74.9 (54.52)	50.1 (38.24)

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention)

Dichotomous outcomes

Outcome	Exoskeleton-assisted anthropomorphic movement training, Baseline, N = 10	Exoskeleton-assisted anthropomorphic movement training, 4 week, N = 10	Conventional therapy, Baseline, N = 10	Conventional therapy, 4 week, N = 10
Withdrawal for any reason	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Exoskeleton-assisted anthropomorphic movement training, Baseline, N = 10	Exoskeleton-assisted anthropomorphic movement training, 4 week, N = 10	Conventional therapy, Baseline, N = 10	Conventional therapy, 4 week, N = 10
No of events				
Adverse events 2 individuals in the exoskeleton group reported muscle fatigue, and 1 in the control group reported shoulder pain, which was relieved after relaxation. No severe adverse events occurred during the study. No of events	n = NA ; % = NA	n = 2 ; % = 20	n = NA ; % = NA	n = 1 ; % = 10

Continuous outcomes

Outcome	Exoskeleton-assisted anthropomorphic movement training, Baseline, N = 10	Exoskeleton-assisted anthropomorphic movement training, 4 week, N = 10	Conventional therapy, Baseline, N = 10	Conventional therapy, 4 week, N = 10
Activities of daily living (Modified Barthel Index) Final values. Scale range 0-100 Mean (SD)	44.2 (13)	71 (12.82)	47.9 (5.88)	66 (11.91)
Function (Fugl-Meyer UE) Final values. Scale range 0-66 Mean (SD)	22.3 (11.42)	35.1 (13.36)	20.2 (9.48)	28.7 (11.27)

Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better
Function (Fugl-Meyer UE) - Polarity - Higher values are better
Also reports ARAT, FM-UA and FM-WH.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Function(Fugl-MeyerUE)-MeanSD-Exoskeleton-assisted anthropomorphic movement training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-Exoskeleton-assisted anthropomorphic movement training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Exoskeleton-assisted anthropomorphic movement training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Exoskeleton-assisted anthropomorphic movement training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Chinembiri, 2021

Bibliographic Reference	Chinembiri, B.; Ming, Z.; Kai, S.; Xiu Fang, Z.; Wei, C.; The fourier M2 robotic machine combined with occupational therapy on post-stroke upper limb function and independence-related quality of life: A randomized clinical trial; Topics in Stroke Rehabilitation; 2021; vol. 28 (no. 1); 1-18

Study details

Secondary publication of another included study- see primary study for details	No additional information
Other publications associated with	No additional information

this study included in review	
Trial name / registration number	ISRCTN = ISRCTN84804721
Study type	Randomised controlled trial (RCT)
Study location	China
Study setting	Outpatient follow up.
Study dates	January 2018 and October 2019.
Sources of funding	Supported by the Jiangsu Provincial Medical Youth Talent under Grant (number QNRC2016376).
Inclusion criteria	Age range 45 to 75 years; stroke diagnosis via MRI or CT scan; post-stroke duration (1-12 months); no comorbidities (e.g. severe heart disease, liver disease, epilepsy, psychiatric problems, infectious or skin diseases); BRS 1 to 4 of the arm; co-operative; only registered at the mentioned hospital.
Exclusion criteria	Unstable patients; history of peripheral nerve injuries; history of neurosurgical treatments; musculoskeletal deformities from other causes; recurrent stroke; BRS >5 of arm; registered in other hospitals.
Recruitment / selection of participants	People at the affiliated Xuzhou Rehabilitation Hospital of Xuzhou Medical University Hospital in China.
Intervention(s)	Robot assisted arm training N=25 Robot and occupational therapy. 50-70 minutes per day, 5 days a week for 6 weeks. Using the Fourier M2 end-effector machine. Allowed for games with real-time trajectory response, robotic assistance that commences when the muscular force is decreased via an installed tactile response software, four progressive training modes that train people from BRS 1 to 6, namely the passive, active-assistive, active and resistive. Concomitant therapy: Both groups received 30 training sessions lasting 50 minutes per day (for the control group and lower end of the intervention group), 5 days a week for a total of 6 weeks.

Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Mixed
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.
Comparator	Usual care N=25 Training involving self-range of motion and passive stretch exercises for the shoulder, elbow, wrist and thumb joints, and muscles (five sets of repetitions) for the first 10 minutes, then a larger selection of upper limb exercises for the next 40 minutes.

	Concomitant therapy: Both groups received 30 training sessions lasting 50 minutes per day (for the control group and lower end of the intervention group), 5 days a week for a total of 6 weeks.
Number of participants	50
Duration of follow-up	6 weeks
Indirectness	No additional information
Additional comments	No additional information. Appears to be ITT.

Study arms

Robot assisted arm training (N = 25)
Robot and occupational therapy. 50-70 minutes per day, 5 days a week for 6 weeks. Using the Fourier M2 end-effector machine. Allowed for games with real-time trajectory response, robotic assistance that commences when the muscular force is decreased via an installed tactile response software, four progressive training modes that train people from BRS 1 to 6, namely the passive, active-assistive, active and resistive. Concomitant therapy: Both groups received 30 training sessions lasting 50 minutes per day (for the control group and lower end of the intervention group), 5 days a week for a total of 6 weeks.

Usual care (N = 25)
Training involving self-range of motion and passive stretch exercises for the shoulder, elbow, wrist and thumb joints, and muscles (five sets of repetitions) for the first 10 minutes, then a larger selection of upper limb exercises for the next 40 minutes. Concomitant therapy: Both groups received 30 training sessions lasting 50 minutes per day (for the control group and lower end of the intervention group), 5 days a week for a total of 6 weeks.

1 **Characteristics**

2 ***Arm-level characteristics***

Characteristic	Robot assisted arm training (N = 25)	Usual care (N = 25)
% Female Sample size	n = NR ; % = NR	n = NR ; % = NR
Mean age (SD) (years) Mean (SD)	57.25 (9.23)	57.72 (7.37)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke Mean (SD)	NR (NR)	NR (NR)

3

4 **Outcomes**

5 ***Study timepoints***

6 • Baseline
7 • 6 week (Post-intervention)

Continuous outcomes

Outcome	Robot assisted arm training, Baseline, N = 20	Robot assisted arm training, 6 week, N = 20	Usual care, Baseline, N = 25	Usual care, 6 week, N = 25
Activities of daily living (barthel index) Scale range: 0-100. Change scores. Mean (SD)	31.8 (10.7)	40 (9.9)	38 (15.2)	10.2 (3.9)
Arm function (Fugl Meyer Assessment Upper Extremity Total score) Scale range: 0-66. Change scores. Mean (SD)	8.9 (7.4)	34 (10.3)	23 (12.2)	12.3 (5.4)

Activities of daily living (barthel index) - Polarity - Higher values are better

Arm function (Fugl Meyer Assessment Upper Extremity Total score) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot assisted arm training, Baseline, N = 25	Robot assisted arm training, 6 week, N = 25	Usual care, Baseline, N = 25	Usual care, 6 week, N = 25
Withdrawal for any reason 5 people did not receive the intervention. 3 withdrew for financial issues. 2 discontinued treatment (discharged). No of events	n = NA ; % = NA	n = 10 ; % = 40	n = NA ; % = NA	n = 0 ; % = 0
Adverse events - Other reported adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - Other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(barthelindex)-MeanSD-Robot assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessmentUpperExtremityTotalscore)-MeanSD-Robot assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-Otherreportedadverseevents-NoOfEvents-Robot assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Conroy, 2011

Bibliographic Reference	Conroy, Susan S.; Whitall, Jill; Dipietro, Laura; Jones-Lush, Lauren M.; Zhan, Min; Finley, Margaret A.; Wittenberg, George F.; Krebs, Hermano I.; Bever, Christopher T.; Effect of gravity on robot-assisted motor training after chronic stroke: a randomized trial; Archives of physical medicine and rehabilitation; 2011; vol. 92 (no. 11); 1754-1761

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months) > 6 months for ischaemic stroke, > 12 months for haemorrhagic stroke.
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot assisted therapy (N = 41)
Group A received robot-assisted planar reaching tasks with the InMotion 2.0 shoulder/ arm over 6 weeks, 3 sessions per week for 1 hour. Group B received robot-assisted planar and vertical reaching tasks with the InMotion Linear Robot over the same time and frequency. The results of the planar group (A) and the planar and vertical group (B) were combined.

Intensive conventional arm exercise (N = 21)
Participants received intensive conventional arm exercise.

Outcomes

Study timepoints

- Baseline
- 6 week (Post-intervention)
- 12 week (Post-intervention)

Continuous outcome

Outcome	Robot assisted therapy, Baseline, N = 41	Robot assisted therapy, 6 week, N = 41	Robot assisted therapy, 12 week, N = 41	Intensive conventional arm exercise, Baseline, N = 21	Intensive conventional arm exercise, 6 week, N = 21	Intensive conventional arm exercise, 12 week, N = 21
Arm function (Fugi-Meyer assesment) Scale range: 0-66. Change scores. Values reported in the Cochrane review used. Mean (SE)	18.5 (2.13)	2.32 (0.53)	2.97 (0.55)	18.2 (2.73)	1.19 (0.78)	1.82 (0.78)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) Scale range: 0-100. Change scores. Values reported in the Cochrane review used.	71.97 (11.25)	3.98 (1.87)	1.09 (1.94)	71.4 (3.1)	-3.19 (2.46)	-2.6 (2.54)

Outcome	Robot assisted therapy, Baseline, N = 41	Robot assisted therapy, 6 week, N = 41	Robot assisted therapy, 12 week, N = 41	Intensive conventional arm exercise, Baseline, N = 21	Intensive conventional arm exercise, 6 week, N = 21	Intensive conventional arm exercise, 12 week, N = 21
Mean (SE)						

Arm function (Fugi-Meyer assesment) - Polarity - Higher values are better
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) - Polarity - Higher values are better
FMA outcome (change scores) Baseline: (mean plus SD): planar group: 20.3 (14.7), planar with vertical group: 16.5 (10.6) Post-intervention (6 weeks): (mean plus SE): planar group: 2.94 (0.77), planar with vertical group: 1.70 (0.80) Post-intervention (12 weeks): (mean plus SE): planar group: 3.30 (0.80), planar with vertical group: 2.61 (0.81) ADL outcome (change scores) Baseline: (mean plus SD): planar group: 73.2 (15.7), planar with vertical group: 70.6 (14.4) Post-intervention (6 weeks): (mean plus SE): planar group: 1.92 (2.74), planar with vertical group: 5.95 (2.74) Post-intervention (12 weeks): (mean plus SE): planar group: 3.29 (2.80), planar with vertical group: -1.35 (2.78) Also reports WMFT outcome.

Dichotomous outcome

Outcome	Robot assisted therapy, Baseline, N = 41	Robot assisted therapy, 6 week, N = 41	Robot assisted therapy, 12 week, N = 41	Intensive conventional arm exercise, Baseline, N = 21	Intensive conventional arm exercise, 6 week, N = 21	Intensive conventional arm exercise, 12 week, N = 21
Withdrawal for any reason 6 weeks: robot group: 5 (1 hospitalisation, 1 social issues, 2 non-compliance, 1 study ended), conventional therapy group: 1 shoulder pain, 1 non-compliance. 12 weeks: robot group: 3 (2 hospitalisation, 1 moved). Conventional therapy group: 0 No of events	n = NA ; % = NA	n = 5 ; % = 12.2	n = 3 ; % = 7	n = NA ; % = NA	n = 2 ; % = 9.52	n = 0 ; % = 0

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Fugi-Meyerassesment)-MeanSE-Robot assisted therapy-Intensive conventional arm exercise-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugi-Meyerassesment)-MeanSE-Robot assisted therapy-Intensive conventional arm exercise-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot assisted therapy-Intensive conventional arm exercise-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot assisted therapy-Intensive conventional arm exercise-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcome-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-MeanSE-Robot assisted therapy-Intensive conventional arm exercise-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-MeanSE-Robot assisted therapy-Intensive conventional arm exercise-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Coote, 2003

Bibliographic Reference	Coote, S.; Stokes, E. K.; The effect of robot mediated therapy on upper extremity function following stroke-initial results; Irish Journal of Medical Science; 2003; vol. 172 (no. 2); 26-7

Study details

Secondary publication of another included study- see primary study for details	Amirabdollahian et a. Multivariate analysis of the Fugl-Meyer outcome measures assessing the effectiveness of GENTLE/S robot-mediated stroke therapy Journal of neuroengineering and rehabilitation; 2007; vol. 4 (no. 1); 1-16
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Coote S, Murphy BT, Stokes EK. The effect of robot mediated therapy on upper extremity function post stroke. 14th International Congress of the World Confederation for Physical Therapy; 2003; Barcelona, Spain. World Confederation for Physical Therapy, 2003.

Coote et al.

Bibliographic Reference	Coote, S.; Stokes, E. K.; Murphy, B. T.; Harwin, W.; The effect of GENTLE/s robot mediated therapy on upper extremity function post stroke; 59-61

Study details

Secondary publication of another included study- see primary study for details	Amirabdollahian et al. Multivariate analysis of the Fugl-Meyer outcome measures assessing the effectiveness of GENTLE/S robot-mediated stroke therapy. Journal of neuroengineering and rehabilitation; 2007; vol. 4 (no. 1); 1-16
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Coote S, Stokes EK. The effect of robot mediated therapy on upper extremity function following stroke - initial results. *Irish Journal of Medical Science* 2003;172(2):26-7.

Coskunsu, 2022

Bibliographic Reference	Coskunsu, DK; Akcay, S; Ogul, OE; Akyol, DK; Ozturk, N; Zileli, F; Tuzun, BB; Krespi, Y; Effects of robotic rehabilitation on recovery of hand functions in acute stroke: a preliminary randomized controlled study; Acta neurologica Scandinavica; 2022; 499-511

Study details

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	No additional information.
Trial name / registration number	NCT03571529
Study type	Randomised controlled trial (RCT)
Study location	Turkey
Study setting	Inpatients in Istanbul Aydın University Medicalpark Florya Hospital
Study dates	No additional information
Sources of funding	Supported by the Rehab Robotic Company.
Inclusion criteria	First ischemic stroke within 4 weeks after onset; being 18 and older; having sitting balance and being able to maintain at least an hour; Montreal Cognitive Assessment Scale 46 score more than 21; visible or palpable contraction (MMT ≥1) in the finger flexor and/or extensor muscles of the hand; full range of motion in MCP, PIP and DIP joints; Modified Ashworth Scale (MAS) ≤ 3 for finger flexors and extensors; willingness to participate in the study.
Exclusion criteria	Other neurologic or orthopedic problems that may affect the upper extremity functions; hemispatial neglect (diagnosed by Line bisection test and The Star Cancellation Test), MAS >3 (constant testing of the spasticity using MAS throughout the rehabilitation)
Recruitment / selection of participants	People admitted to Istanbul Aydın University Medicalpark Florya Hospital.
Intervention(s)	Robot-assisted arm training N=12 Robot assisted rehabilitation in addition to usual care. Hand of Hope (an EMG-driven exoskeleton) robot device used daily, 5 days/week for 3 consecutive weeks (totally 15 sessions). There were three treatment modes: Continuous Passive Motion (CPM), trigger&go and trigger&maintain. The system also had 3 different options for treatment: hand grasping, hand opening and hand grasping & opening. The patient's hand was placed inside the robot and fixed with velcro. Surface EMG

	electrodes were placed on the ED and FDS muscles according to the user manual of the device. Each robot-assisted training session lasted for approximately 1 h. Each treatment protocol was as follows: Initially treatment started with CPM mode for 10 min for warming up, then hand opening and grasping in the trigger&go or trigger&maintain mode, hand opening in the trigger&go or trigger&maintain mode and hand grasping in the trigger&go or trigger&maintain mode, each 10 min in duration, applied sequentially with 2 min of resting between sequences. Concomitant therapy: Everyone received rehabilitation exercises for 1 hour (30 minutes for the upper extremity, 30 minutes for the lower extremity). These consisted of early Bobath exercises, neurophysiological approaches including combinations of Brunnstrom, Johnstone and PNF exercises and electrical stimulation selected according to the patient's condition.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

Population subgroups	No additional information.
Comparator	Any other intervention (usual care) N=12 Usual care. Concomitant therapy: Everyone received rehabilitation exercises for 1 hour (30 minutes for the upper extremity, 30 minutes for the lower extremity). These consisted of early Bobath exercises, neurophysiological approaches including combinations of Brunnstrom, Johnstone and PNF exercises and electrical stimulation selected according to the patient's condition.
Number of participants	24
Duration of follow-up	3 weeks
Indirectness	No additional information.
Additional comments	No additional information. Method of analysis unclear, appears to be completers only.

Study arms

Robot-assisted arm training (N = 12)
Robot assisted rehabilitation in addition to usual care. Hand of Hope (an EMG-driven exoskeleton) robot device used daily, 5 days/week for 3 consecutive weeks (totally 15 sessions). There were three treatment modes: Continuous Passive Motion (CPM), trigger&go and trigger&maintain. The system also had 3 different options for treatment: hand grasping, hand opening and hand grasping & opening. The patient's hand was placed inside the robot and fixed with velcro. Surface EMG electrodes were placed on the ED and FDS muscles according to the user manual of the device. Each robot-assisted training session lasted for approximately 1 h. Each treatment protocol was as follows: Initially treatment started with CPM mode for 10 min for warming up, then hand opening and grasping in the trigger&go or trigger&maintain mode, hand opening in the trigger&go or trigger&maintain mode and hand grasping in the trigger&go or trigger&maintain mode, each 10 min in duration, applied sequentially with 2 min of resting between sequences.

Concomitant therapy: Everyone received rehabilitation exercises for 1 hour (30 minutes for the upper extremity, 30 minutes for the lower extremity). These consisted of early Bobath exercises, neurophysiological approaches including combinations of Brunnstrom, Johnstone and PNF exercises and electrical stimulation selected according to the patient's condition.

Any other intervention (usual care) (N = 12)

Usual care. Concomitant therapy: Everyone received rehabilitation exercises for 1 hour (30 minutes for the upper extremity, 30 minutes for the lower extremity). These consisted of early Bobath exercises, neurophysiological approaches including combinations of Brunnstrom, Johnstone and PNF exercises and electrical stimulation selected according to the patient's condition.

Characteristics

Arm-level characteristics

Characteristic	**Robot-assisted arm training (N = 12)**	**Any other intervention (usual care) (N = 12)**
% Female Sample size	n = 7 ; % = 64	n = 2 ; % = 22
Mean age (SD) (years) Mean (SD)	59.9 (14.3)	70 (14)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm training (N = 12)	Any other intervention (usual care) (N = 12)
Sample size		
Time after stroke Mean (SD)	NR (NR)	NR (NR)

Outcomes

Study timepoints

- Baseline
- 3 week (Post-intervention)

Continuous outcome

Outcome	Robot-assisted arm training, Baseline, N = 11	Robot-assisted arm training, 3 week, N = 11	Any other intervention (usual care), Baseline, N = 9	Any other intervention (usual care), 3 week, N = 9
Arm function (ARAT total score) Scale range: 0-57. Change scores. Mean (SD)	20.27 (21.31)	15.73 (14.41)	12.67 (12.76)	20 (11.61)

Arm function (ARAT total score) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot-assisted arm training, Baseline, N = 12	Robot-assisted arm training, 3 week, N = 12	Any other intervention (usual care), Baseline, N = 12	Any other intervention (usual care), 3 week, N = 12
Withdrawal for any reason intervention reasons - (Takeayasu's arteritis). Control - distance, cardiac operation) No of events	n = NA ; % = NA	n = 1 ; % = 8.3	n = NA ; % = NA	n = 3 ; % = 25

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Physicalfunction-upperlimb(ARATtotalscore)-MeanSD-Robot-assisted arm training-Any other intervention (usual care)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Any other intervention (usual care)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Daly, 2005

Bibliographic Reference	Daly, Janis J.; Hogan, Neville; Perepezko, Elizabeth M.; Krebs, Hermano I.; Rogers, Jean M.; Goyal, Kanu S.; Dohring, Mark E.; Fredrickson, Eric; Nethery, Joan; Ruff, Robert L.; Response to upper-limb robotics and functional neuromuscular stimulation following stroke; Journal of rehabilitation research & development; 2005; vol. 42 (no. 6)

Study details

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	≥1 hour

Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robotics and motor training (N = 7)
5 hours per day, 5 days a week for 12 weeks. 1.5 hours per session for robotics shoulder and elbow training.

Functional neuromuscular stimulation and motor training (N = 6)
5 hours per day, 5 days a week for 12 weeks. 1.5 hours per session for functional neuromuscular stimulation.

Outcomes

Study timepoints
- Baseline
- 3 month (Post-intervention)

Continuous outcomes

Outcome	Robotics and motor training, Baseline, N = 7	Robotics and motor training, 3 month, N = 7	Functional neuromuscular stimulation and motor training, Baseline, N = 6	Functional neuromuscular stimulation and motor training, 3 month, N = 6
Arm function (Fugl-Meyer assessment) Scale range: 0-66. Change scores. Values reported in the Cochrane review used. Mean (SD)	NR (NR)	8.2 (7.3)	NR (NR)	9.5 (8)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Also reports AMAT and motor control outcomes.

Dichotomous outcomes

Outcome	Robotics and motor training, Baseline, N = 7	Robotics and motor training, 3 month, N = 7	Functional neuromuscular stimulation and motor training, Baseline, N = 6	Functional neuromuscular stimulation and motor training, 3 month, N = 6
Withdrawal for any reason Dropped out of the study for personal reasons. No of events	n = NA ; % = NA	n = 1 ; % = 14.3	n = NA ; % = NA	n = 0 ; % = 0
Adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robotics and motor training-Functional neuromuscular stimulation and motor training-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robotics and motor training-Functional neuromuscular stimulation and motor training-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Daly et al.

Bibliographic Reference	Daly, Janis J.; Rogers, Jean; McCabe, Jessica; Monkiewicz, Michelle; Burdsall, Richard; Pundik, Svetlana; Recovery of actual functional tasks in response to motor learning, robotics, and functional electrical stimulation; vol. 41; E355-E356

Study details

Secondary publication of another included	McCabe J, Monkiewicz M, Holcomb J, Pundik S, Daly JJ. Comparison of robotics, functional electrical stimulation, and motor learning methods for treatment of persistent upper extremity dysfunction after stroke: a randomized controlled trial. *Archives of Physical Medicine and Rehabilitation* 2015;96(6):981-90.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Daunoraviciene, 2018

Bibliographic Reference	Daunoraviciene, K.; Adomaviciene, A.; Grigonyte, A.; Griskevicius, J.; Juocevicius, A.; Effects of robot-assisted training on upper limb functional recovery during the rehabilitation of poststroke patients; Technology & Health Care; 2018; vol. 26 (no. s2); 533-542

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	No additional information.

Study type	Randomised controlled trial (RCT)
Study location	Lithuania
Study setting	Outpatient follow up
Study dates	No additional information.
Sources of funding	No additional information.
Inclusion criteria	Experienced an ischaemic or haemorrhagic stroke; aged 60-74 years old and older; had stroke-affected arm paresis; experienced disturbed deep and superficial sensations and achieved a Mini-Mental Stat test score >21 points.
Exclusion criteria	Stroke-affected arm paralysis; were at less than 60 years old; achieved a MMS test score <21 points; had aphasia; experienced shoulder or wrist pain syndrome; hypertonic stroke-affected arm.
Recruitment / selection of participants	No additional information.
Intervention(s)	Robot-assisted arm training N=17 Armeo Spring training for 30 minutes a day for 10 sessions (5 days a week). Robotic training was administered under the supervision of an occupational therapist who adjusted the patient to their therapy by setting their parameters and therapy conditions. Included a sequence of motor tasks with a short resting phase. Concomitant therapy: Conventional functional rehabilitation for 35-60 minutes/day in approximately 10 occupational therapy sessions (including exercising, physical activities, active table games etc.).
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear

Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information
Comparator	Usual care N=17 30 minutes on 5 days a week of conventional functional rehabilitation. Concomitant therapy: Conventional functional rehabilitation for 35-60 minutes/day in approximately 10 occupational therapy sessions (including exercising, physical activities, active table games etc.).
Number of participants	34
Duration of follow-up	2 weeks (post-intervention)
Indirectness	No additional information
Additional comments	No additional information

1

Study arms

Robot-assisted arm training (N = 17)
Armeo Spring training for 30 minutes a day for 10 sessions (5 days a week). Robotic training was administered under the supervision of an occupational therapist who adjusted the patient to their therapy by setting their parameters and therapy conditions. Included a sequence of motor tasks with a short resting phase. Concomitant therapy: Conventional functional rehabilitation for 35-60 minutes/day in approximately 10 occupational therapy sessions (including exercising, physical activities, active table games etc.).

Usual care (N = 17)
30 minutes on 5 days a week of conventional functional rehabilitation. Concomitant therapy: Conventional functional rehabilitation for 35-60 minutes/day in approximately 10 occupational therapy sessions (including exercising, physical activities, active table games etc.).

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 17)	Usual care (N = 17)
% Female Sample size	n = 6 ; % = 35	n = 6 ; % = 35
Mean age (SD) (years) Mean (SD)	65.88 (4.87)	65.47 (4.05)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm training (N = 17)	Usual care (N = 17)
Sample size		
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (Weeks) Mean (SD)	8.64 (3.53)	9.65 (6.18)

Outcomes

Study timepoints

- Baseline
- 2 week (Post-intervention)

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 17	Robot-assisted arm training, 2 week, N = 17	Usual care, Baseline, N = 17	Usual care, 2 week, N = 17
Activities of daily living (modified FIM score) 6 item self-care scale. Scale range: 6-42. final values Mean (SD)	24.41 (5.18)	31.94 (4.39)	25.76 (8.16)	27.76 (7.62)
Arm function (Fugl Meyer Assessment Upper Extremity) Scale range: 0-66. final values Mean (SD)	32.18 (16.53)	45.17 (18.48)	32.06 (16.18)	41.76 (15.41)

Outcome	Robot-assisted arm training, Baseline, N = 17	Robot-assisted arm training, 2 week, N = 17	Usual care, Baseline, N = 17	Usual care, 2 week, N = 17
Spasticity (modified Ashworth scale) Scale range: 0-5. Final values. Individual patient data provided which was converted to continuous data (shoulder, elbow and wrist values combined). Mean (SD)	0.45 (0.86)	0.59 (0.97)	0.47 (0.78)	0.85 (1.1)

Activities of daily living (modified FIM score) - Polarity - Higher values are better
Arm function (Fugl Meyer Assessment Upper Extremity) - Polarity - Higher values are better
Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(modifiedFIMscore)-MeanSD-Robot-assisted arm training-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessmentUpperExtremity)-MeanSD-Robot-assisted arm training-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm training-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dehem, 2019

Bibliographic Reference	Dehem, S.; Gilliaux, M.; Stoquart, G.; Detrembleur, C.; Jacquemin, G.; Palumbo, S.; Frederick, A.; Lejeune, T.; Effectiveness of upper-limb robotic-assisted therapy in the early rehabilitation phase after stroke: A single-blind, randomised, controlled trial; Annals of Physical & Rehabilitation Medicine; 2019; vol. 62 (no. 5); 313-320

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with	No additional information.

this study included in review	
Trial name / registration number	Clinicaltrials.gov = NCT02079779
Study type	Randomised controlled trial (RCT)
Study location	Belgium
Study setting	Three Belgian inpatient rehabilitation centres: Cliniques universitaries Saint-Luc (Brussels), Centre Hospitalier Valida (Brussels) and Centre Hospitalier Neurologique William Lennox (Ottignies).
Study dates	May 2014 to May 2017
Sources of funding	This work was supported by the Region Wallone, the Fondation Motrice and the Fondation Saint-Luc. The authors thank Axinesis (Wavre, Belgium) for development of the robot REAplan and Fishing Cactus (Mons, Belgium) for development of the game.
Inclusion criteria	Single first ischaemic or haemorrhagic stroke; <1 month delay since stroke; age at least 18 years old; Mini-Mental State Examination score at least 15; the ability to understand instructions; FMA-Upper Extremity score <80%, assessed by the computerized adaptive testing system (a higher score indicating less upper limb motor impairments); a health status allowing for rehabilitation.
Exclusion criteria	Stroke located in the brain stem or cerebellum or another orthopaedic or neurological disease altering the paretic upper limb function.
Recruitment / selection of participants	People recruited from three inpatient rehabilitation centres.
Intervention(s)	Robot-assisted arm training N=23 REAplan(R) robot arm therapy. 45 minutes sessions supervised by a therapist. 4 sessions of conventional therapy per week was replaced and was completed for 9 weeks in total. The exercises were similar in each centre and consisted of a game, involving moving the paretic hand along a reference trajectory while passing through checkpoints (for example: golf paths and golf balls). During the game the robot guided participants with assistance as needed.

	Concomitant therapy: Both groups underwent their rehabilitation sessions during their hospitalisation with their regular physical therapists and occupational therapists.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	No additional information
Comparator	Usual care N=22 Conventional therapy focused on motor rehabilitation, matched with their personal needs and centre's means.

	Concomitant therapy: Both groups underwent their rehabilitation sessions during their hospitalisation with their regular physical therapists and occupational therapists.
Number of participants	45
Duration of follow-up	6 months in total (followed up at 9 weeks and 6 months)
Indirectness	No additional information
Additional comments	Method of analysis unclear. Appears to be only completers.

Study arms

Robot-assisted arm training (N = 23)
REAplan(R) robot arm therapy. 45 minutes sessions supervised by a therapist. 4 sessions of conventional therapy per week was replaced and was completed for 9 weeks in total. The exercises were similar in each centre and consisted of a game, involving moving the paretic hand along a reference trajectory while passing through checkpoints (for example: golf paths and golf balls). During the game the robot guided participants with assistance as needed. Concomitant therapy: Both groups underwent their rehabilitation sessions during their hospitalisation with their regular physical therapists and occupational therapists.

Usual care (N = 22)
Conventional therapy focused on motor rehabilitation, matched with their personal needs and centre's means. Concomitant therapy: Both groups underwent their rehabilitation sessions during their hospitalisation with their regular physical therapists and occupational therapists.

1 **Characteristics**

2 ***Arm-level characteristics***

Characteristic	Robot-assisted arm training (N = 23)	Usual care (N = 22)
% Female Sample size	n = 12 ; % = 52	n = 12 ; % = 55
Mean age (SD) (years) Mean (SD)	67.3 (11.1)	68.6 (19.1)
Ethnicity Sample size	n = NA ; % = NA	n = NA ; % = NA
Comorbidities Sample size	n = NA ; % = NA	n = NA ; % = NA
Severity Sample size	n = NA ; % = NA	n = NA ; % = NA
Time after stroke Sample size	n = NA ; % = NA	n = NA ; % = NA

3

4 **Outcomes**

5 ***Study timepoints***

6 • Baseline
7 • 9 week (Post-intervention)
8 • 6 month (≥6 months)

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 23	Robot-assisted arm training, 9 week, N = 15	Robot-assisted arm training, 6 month, N = 15	Usual care, Baseline, N = 22	Usual care, 9 week, N = 17	Usual care, 6 month, N = 13
Arm function (Fugl-Meyer assessment- upper extremity) (%) Scale range: 0-100. Final values. Mean (SD)	32.4 (25.4)	51.9 (30.9)	57.1 (33.8)	31.6 (27)	42.4 (32.6)	41.6 (34.5)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) (%) Scale range: 0-100 Mean (SD)	36.3 (21.4)	50 (21.4)	59.4 (24.1)	45.2 (26.6)	50.9 (34.7)	47.5 (31.5)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 23	Robot-assisted arm training, 9 week, N = 23	Robot-assisted arm training, 6 month, N = 23	Usual care, Baseline, N = 22	Usual care, 9 week, N = 22	Usual care, 6 month, N = 22
Withdrawal for any reason Robot assisted therapy: 8 dropped out between pre- and post-intervention (3 health worsening, 2 personal choice, 1 shoulder pain, 1 many missing sessions, 1 death). Control: 5	n = NA ; % = NA	n = 8 ; % = 35	n = 8 ; % = 35	n = NA ; % = NA	n = 5 ; % = 23	n = 9 ; % = 41

Outcome	Robot-assisted arm training, Baseline, N = 23	Robot-assisted arm training, 9 week, N = 23	Robot-assisted arm training, 6 month, N = 23	Usual care, Baseline, N = 22	Usual care, 9 week, N = 22	Usual care, 6 month, N = 22
drop out between pre- and post-intervention (3 health worsening, 1 stroke recurrence, 1 discharge without possibility to pursue the protocol. 4 drop-out between post-intervention and 6 months post stroke (2 unreachable, 1 death, 1 personal choice). No of events						
Adverse events - Other reported adverse events Intervention: 1 shoulder pain, 1 death. Control group: 1 stroke recurrent, 1 death between post-intervention and 6 months. No of events	n = NA ; % = NA	n = 2 ; % = 9	n = 2 ; % = 9	n = NA ; % = NA	n = 1 ; % = 5	n = 2 ; % = 9

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - Other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm training-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-MeanSD-Robot-assisted arm training-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-MeanSD-Robot-assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot-assisted arm training-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot-assisted arm training-Usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Fasoli, 2004

Bibliographic Reference	Fasoli, Susan E.; Krebs, Hermano I.; Ferraro, Mark; Hogan, Neville; Volpe, Bruce T.; Does shorter rehabilitation limit potential recovery poststroke?; Neurorehabilitation and neural repair; 2004; vol. 18 (no. 2); 88-94

Study details

Secondary publication of another included study- see primary study for details	Volpe et al. A novel approach to stroke rehabilitation: robot-aided sensorimotor stimulation. Neurology; 2000; vol. 54 (no. 10); 1938-1944
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Fazekas, 2007

Bibliographic Reference	Fazekas, Gabor; Horvath, Monika; Troznai, Tibor; Toth, Andras; Robot-mediated upper limb physiotherapy for patients with spastic hemiparesis: a preliminary study; Journal of rehabilitation medicine; 2007; vol. 39 (no. 7); 580-582

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour 30 minutes robot therapy, plus 30 minutes Bobath therapy.
Subgroup 5: Dose (days per week)	Not stated/unclear '20 consecutive workdays'.
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear

Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot therapy (N = 15)
30 minutes of Bobath therapy sessions on 20 consecutive days, plus an additional 30 minutes of robot therapy.

Control group (N = 15)
30 minutes of Bobath therapy sessions on 20 consecutive days.

Outcomes

Study timepoints
- Baseline
- 20 day (Post-intervention.)

Dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 20 day, N = 15	Control group, Baseline, N = 15	Control group, 20 day, N = 15
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 20 day, N = 15	Control group, Baseline, N = 15	Control group, 20 day, N = 15
Adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 20 day, N = 15	Control group, Baseline, N = 15	Control group, 20 day, N = 15
Activities of daiy living (FIM self-care) Change scores. Score range 6-42. Values as reported in Cochrane review. Mean (SD)	NR (NR)	12.07 (9.26)	NR (NR)	25.53 (14.32)
Arm function (Fugl-Meyer shoulder-elbow subsection) Change scores. Score range 0-36. Values as reported in Cochrane review. Mean (SD)	NR (NR)	5.53 (1.38)	NR (NR)	2.6 (1.77)
Spasticity (Modified Ashworth of shoulder adductors) Change scores. Score range 0-5. Reported mean final values and p value for the change from baseline. Mean (SD)	NA (NA)	NA (NA)	NA (NA)	NA (NA)
Spasticity (Modified Ashworth of shoulder adductors) Change scores. Score range 0-5. Reported mean final values and p value for the change from baseline. Mean (p value)	NA (NA)	NA (NA)	NA (NA)	NA (NA)

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 20 day, N = 15	Control group, Baseline, N = 15	Control group, 20 day, N = 15
Modified Ashworth of shoulder adductors Mean (SD)	NA (NA)	NA (NA)	NA (NA)	NA (NA)
Modified Ashworth of shoulder adductors Mean (p value)	1.93 (NR)	-0.73 (0.011)	1.67 (NR)	-0.2 (0.56)
Modified Ashworth of elbow flexors Mean (SD)	NA (NA)	NA (NA)	NA (NA)	NA (NA)
Modified Ashworth of elbow flexors Mean (p value)	2.87 (NR)	-0.74 (0.021)	2.13 (NR)	0 (0.71)

Activities of daiy living (FIM self-care) - Polarity - Higher values are better
Arm function (Fugl-Meyer shoulder-elbow subsection) - Polarity - Higher values are better
Spasticity (Modified Ashworth of shoulder adductors) - Polarity - Lower values are better
Also reports Rivermead arm score, ROM (range of motion) scores.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotmousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdaiyliving(FIMself-care)-MeanSD-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyershoulder-elbowsubsection)-MeanSD-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(ModifiedAshworthofshoulderadductors)-ModifiedAshworthofshoulderadductors-MeanSD-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(ModifiedAshworthofshoulderadductors)-ModifiedAshworthofelbowflexors-MeanSD-Robot therapy-Control group-t20

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Fernandez-Garcia, 2021

Bibliographic Reference	Fernandez-Garcia, C.; Ternent, L.; Homer, T. M.; Rodgers, H.; Bosomworth, H.; Shaw, L.; Aird, L.; Andole, S.; Cohen, D.; Dawson, J.; Finch, T.; Ford, G.; Francis, R.; Hogg, S.; Hughes, N.; Krebs, H. I.; Price, C.; Turner, D.; Van Wijck, F.; Wilkes, S.; Wilson, N.; Vale, L.; Economic evaluation of robot-assisted training versus an enhanced upper limb therapy programme or usual care for patients with moderate or severe upper limb functional limitation due to stroke: results from the RATULS randomised controlled trial; BMJ Open; 2021; vol. 11 (no. 5); e042081

Study details

Secondary publication of	Rodgers H, Bosomworth H, Krebs HI, van Wijck F, Howel D, Wilson N, Aird L, Alvarado N, Andole S, Cohen DL, Dawson J, Fernandez-Garcia C, Finch T, Ford GA, Francis R, Hogg S, Hughes N, Price CI, Ternent L, Turner DL, Vale L, Wilkes S,

another included study- see primary study for details	Shaw L. Robot assisted training for the upper limb after stroke (RATULS): a multicentre randomised controlled trial. Lancet. 2019 Jul 6;394(10192):51-62. doi: 10.1016/S0140-6736(19)31055-4. Epub 2019 May 22. PMID: 31128926; PMCID: PMC6620612.
Other publications associated with this study included in review	Rodgers H, Bosomworth H, Krebs HI, van Wijck F, Howel D, Wilson N, Finch T, Alvarado N, Ternent L, Fernandez-Garcia C, Aird L, Andole S, Cohen DL, Dawson J, Ford GA, Francis R, Hogg S, Hughes N, Price CI, Turner DL, Vale L, Wilkes S, Shaw L. Robot-assisted training compared with an enhanced upper limb therapy programme and with usual care for upper limb functional limitation after stroke: the RATULS three-group RCT. Health Technol Assess. 2020 Oct;24(54):1-232. doi: 10.3310/hta24540. PMID: 33140719; PMCID: PMC7682262.

Franceschini, 2020

Bibliographic Reference	Franceschini, M.; Mazzoleni, S.; Goffredo, M.; Pournajaf, S.; Galafate, D.; Criscuolo, S.; Agosti, M.; Posteraro, F.; Upper limb robot-assisted rehabilitation versus physical therapy on subacute stroke patients: A follow-up study; Journal of Bodywork & Movement Therapies; 2020; vol. 24 (no. 1); 194-198

Study details

Secondary publication of another included study- see primary study for details	Sale et al. Effects of upper limb robot-assisted therapy on motor recovery in subacute stroke patients. J Neuroeng Rehabil. 2014; 11: 104.

Frisoli, 2022

Bibliographic Reference	Frisoli, A; Barsotti, M; Sotgiu, E; Lamola, G; Procopio, C; Chisari, C; A randomized clinical control study on the efficacy of three-dimensional upper limb robotic exoskeleton training in chronic stroke; Journal of neuroengineering and rehabilitation; 2022; vol. 19 (no. 1); 14

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	NCT03319992
Study type	Randomised controlled trial (RCT)
Study location	Italy.
Study setting	Outpatient follow up.
Study dates	No additional information.
Sources of funding	Partially funded by SKILLS EU FP7 project. Dr Barsotti is funded by an "Cassa di Risparmio of Florence" Postgraduate Fellowship.
Inclusion criteria	Age ranged between 30 and 80 years; diagnosis of a first-ever left hemisphere ischaemic or haemorrhagic stroke at least 6 months prior to entry into the study; minimum ability for shoulder humeral elevation; upper-extremity motor function FMA score at least 15 (out of 66); absence of neurological or muscular disorders that interfere with neuromuscular function;

	absence of severe cognitive deficits that would limit patients' ability to complete the study; minimum score of 2 in the Modified Ashworth Scale.
Exclusion criteria	Participating in any experimental rehabilitation or drug studies at the same time; previous experience with robotic treatments.
Recruitment / selection of participants	People were recruited from the pool of outpatients of the Neurorehabilitation Unit of the University Hospital of Pisa.
Intervention(s)	Robot-assisted arm therapy N=13 L-EXOS robotic exoskeleton with a virtual reality rehabilitation exercise program for 3 weekly sessions of 45 minutes each over 6 weeks. People were set in front of a 46 inches LCD screen placed at least 1m away wearing stereoscopic glasses and the robot placed on their right (impaired) upper limb. People using a wheel chair had their arm rest removed to not interfere with the robot. The robot was used for reaching and manipulation exercises that required visuo-motor coordination. The robot provided active assistance to movement. Concomitant therapy: No additional information.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week

Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	No additional information.
Comparator	Any other intervention N=13 Manual rehabilitation including passive movement, goal directed movement and voluntary action for the same time period as the intervention group. Concomitant therapy: No additional information.
Number of participants	26
Duration of follow-up	6 weeks (end of intervention).
Indirectness	No additional information.
Additional comments	Method of analysis unclear (appears to be completers only).

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Study arms

Robot-assisted arm therapy (N = 13)
L-EXOS robotic exoskeleton with a virtual reality rehabilitation exercise program for 3 weekly sessions of 45 minutes each over 6 weeks. People were set in front of a 46 inches LCD screen placed at least 1m away wearing stereoscopic glasses and the robot placed on their right (impaired) upper limb. People using a wheel chair had their arm rest removed to not interfere with the robot. The robot was used for reaching and manipulation exercises that required visuo-motor coordination. The robot provided active assistance to movement. Concomitant therapy: No additional information.

Any other intervention (N = 13)
Manual rehabilitation including passive movement, goal directed movement and voluntary action for the same time period as the intervention group. Concomitant therapy: No additional information.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm therapy (N = 13)	Any other intervention (N = 13)
% Female Sample size	n = 4 ; % = 36	n = 3 ; % = 27
Mean age (SD) (years) Mean (SD)	62 (12)	70 (11)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm therapy (N = 13)	Any other intervention (N = 13)
Sample size		
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (Months) Mean (SD)	30 (20)	37 (24)

Reports baseline characteristics for only 11 people in each study arm.

Outcomes

Study timepoints

- Baseline
- 6 week (End of intervention)

Continuous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 11	Robot-assisted arm therapy, 6 week, N = 11	Any other intervention, Baseline, N = 11	Any other intervention, 6 week, N = 11
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Change scores. Mean (SD)	25.6 (12.3)	11.1 (13.9)	26.7 (16.3)	8.9 (17.6)
Spasticity (modified Ashworth scale)	17.1 (11.5)	1.5 (13.7)	20.6 (9.8)	1.4 (11.5)

Outcome	Robot-assisted arm therapy, Baseline, N = 11	Robot-assisted arm therapy, 6 week, N = 11	Any other intervention, Baseline, N = 11	Any other intervention, 6 week, N = 11
Scale range: unclear. Change scores. Mean (SD)				

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Dichotomous outcome

Outcome	Robot-assisted arm therapy, Baseline, N = 13	Robot-assisted arm therapy, 6 week, N = 13	Any other intervention, Baseline, N = 13	Any other intervention, 6 week, N = 13
Withdrawal for any reason Intervention: medical reason unrelated to the study (2), Control: psychological reasons (1), did not come at final evaluation (1) No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm therapy-Any other intervention-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm therapy-Any other intervention-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Any other intervention-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Gandolfi, 2019

Bibliographic Reference	Gandolfi, M.; Vale, N.; Dimitrova, E. K.; Mazzoleni, S.; Battini, E.; Filippetti, M.; Picelli, A.; Santamato, A.; Gravina, M.; Saltuari, L.; Smania, N.; Effectiveness of Robot-Assisted Upper Limb Training on Spasticity, Function and Muscle Activity in Chronic

Stroke Patients Treated With Botulinum Toxin: A Randomized Single-Blinded Controlled Trial; Frontiers in neurology [electronic resource].; 2019; vol. 10; 41

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	Clinicaltrials.gov = NCT03590314
Study type	Randomised controlled trial (RCT)
Study location	Italy.
Study setting	People referred to the Neurorehabilitation Unit (AOUI Verona) and the Physical Medicine and Rehabilitation Section, "OORR" Hospital (University of Foggia).
Study dates	February 2017 to April 2018.
Sources of funding	No additional information.
Inclusion criteria	Age >18 years; diagnosis of ischaemic or haemorrhagic first-ever stroke as documented by a computerized tomography scan or magnetic resonance imaging; at least 6 months since stroke; Modified Ashworth Scale score (shoulder and elbow) no more than 3 and at least 1+; botulinum toxin injection within the previous 12 weeks of at least one of the muscles of the affected upper limb; Mini-Mental State Examination score at least 24; Trunk Control Test score = 100/100.
Exclusion criteria	Any rehabilitation intervention in the 3 months before recruitment; bilateral cerebrovascular lesion; severe neuropsychologic impairment (global aphasia, severe attention deficit or neglect); joint orthopedic disorders.

Recruitment / selection of participants	Chronic post-stroke patients with upper-limb spasticity referred tot eh Neurorehabilitation Unit (AOUI Verona) and the Physical Medicine and Rehabilitation Section, "OORR" Hospital (University of Foggia).
Intervention(s)	Robot-assisted arm training N=16 Robot-assisted upper limb training and botulinum toxin A treatment (onabotulinum toxin A, abobotulinum toxin A or incobotulinumtoxin A). Robot-assisted upper limb training with an Armotion device. Could provide passive, active, passive-active, perturbative and assistive modes. The robot-assisted upper limb training consisted of passive mobilisation and stretching exercises for the affected upper limb (10 minutes) followed by robot-assisted exercises (35 minutes). 2 sessions per week for 5 consecutive weeks. Four types of exercises contained within the Armotion software and amount of repetitions were selected. All exercises were oriented to achieving several goals in various directions, emphasizing the elbow flexion-extension and reaching movement. The robot allows participants to execute the exercises through an "assisted as needed" control strategy. The difficulty was increased over time by varying the assisted and non-assisted modality and increasing the number of repetitions. Concomitant therapy: All people received botulinum toxin A treatment. The dose, volume and number of injection sites were set according to the severity of spasticity.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week

Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information
Comparator	Conventional training N=16 Conventional training and botulinum toxin A treatment. Conventional training consisting of upper limb passive mobilisation and stretching (10 minutes) followed by upper limb exercises (35 minutes) that incorporated single or multi-joint movements for the scapula, shoulder and elbow, performed in different positions (i.e. supine and standing position). 2 sessions per week for 5 consecutive weeks. The increase in difficulty and progression were obtained by increasing range of motion, repetitions and performing movements against gravity or slight resistance. Concomitant therapy: All people received botulinum toxin A treatment. The dose, volume and number of injection sites were set according to the severity of spasticity.
Number of participants	32
Duration of follow-up	5 weeks (end of intervention)
Indirectness	No additional information
Additional comments	Intention to treat

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Study arms

Robot-assisted arm training (N = 16)

Robot-assisted upper limb training and botulinum toxin A treatment (onabotulinum toxin A, abobotulinum toxin A or incobotulinumtoxin A). Robot-assisted upper limb training with an Armotion device. Could provide passive, active, passive-active, perturbative and assistive modes. The robot-assisted upper limb training consisted of passive mobilisation and stretching exercises for the affected upper limb (10 minutes) followed by robot-assisted exercises (35 minutes). 2 sessions per week for 5 consecutive weeks. Four types of exercises contained within the Armotion software and amount of repetitions were selected. All exercises were oriented to achieving several goals in various directions, emphasizing the elbow flexion-extension and reaching movement. The robot allows participants to execute the exercises through an "assisted as needed" control strategy. The difficulty was increased over time by varying the assisted and non-assisted modality and increasing the number of repetitions. Concomitant therapy: All people received botulinum toxin A treatment. The dose, volume and number of injection sites were set according to the severity of spasticity.

Conventional training (N = 16)

Conventional training and botulinum toxin A treatment. Conventional training consisting of upper limb passive mobilisation and stretching (10 minutes) followed by upper limb exercises (35 minutes) that incorporated single or multi-joint movements for the scapula, shoulder and elbow, performed in different positions (i.e. supine and standing position). 2 sessions per week for 5 consecutive weeks. The increase in difficulty and progression were obtained by increasing range of motion, repetitions and performing movements against gravity or slight resistance. Concomitant therapy: All people received botulinum toxin A treatment. The dose, volume and number of injection sites were set according to the severity of spasticity.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 16)	Conventional training (N = 16)
% Female Sample size	n = 4 ; % = 25	n = 6 ; % = 38

Characteristic	Robot-assisted arm training (N = 16)	Conventional training (N = 16)
Mean age (SD) (years) Mean (SD)	59.31 (14.4)	59.13 (14.97)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (years) Mean (SD)	6 (3.1)	5.1 (2.2)

Outcomes

Study timepoints

- Baseline
- 5 week (Post-intervention)

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 16	Robot-assisted arm training, 5 week, N = 16	Conventional training, Baseline, N = 16	Conventional training, 5 week, N = 16
Arm function (Fugl-Meyer assessment) Scale range: 0-66. Change scores. Mean (95% CI)	NA (NA to NA)	3.62 (1.77 to 5.48)	NA (NA to NA)	6.56 (3.75 to 9.36)
Arm function (Fugl-Meyer assessment) Scale range: 0-66. Change scores. Mean (SD)	28.75 (11.92)	NA (NR)	27.94 (10.82)	NA (NR)
Arm muscle strength (Medical Research Council scale) Scale range: 0-40. Change scores. Mean (95% CI)	23 (14.37 to 25.25)	3.62 (2.16 to 5.08)	23 (16.12 to 28.37)	0.9 (-0.31 to 2.13)
Spasticity (modified Ashworth scale) Scale range: 0-5. Change scores. Mean (95% CI)	NA (NA to NA)	3.62 (1.77 to 5.48)	NA (NA to NA)	6.56 (3.75 to 9.36)
Spasticity (modified Ashworth scale) Scale range: 0-5. Change scores. Mean (SD)	28.75 (11.92)	NA (NR)	27.94 (10.82)	NA (NR)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm muscle strength (Medical Research Council scale) - Polarity - Higher values are better
Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Dichotomous outcome

Outcome	Robot-assisted arm training, Baseline, N = 16	Robot-assisted arm training, 5 week, N = 16	Conventional training, Baseline, N = 16	Conventional training, 5 week, N = 16
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanNineFivePercentCI-Robot-assisted arm training-Conventional training-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MedicalResearchCouncilscale)-MeanNineFivePercentCI-Robot-assisted arm training-Conventional training-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanNineFivePercentCI-Robot-assisted arm training-Conventional training-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Conventional training-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Grigoras, 2016

Bibliographic Reference	Grigoras, Alexandra Valer; Irimia, Danut Constantin; Poboroniuc, Marian Silviu; Popescu, Cristian Dinu; Testing of a hybrid FES-robot assisted hand motor training program in sub-acute stroke survivors; Advances in Electrical and Computer Engineering; 2016; vol. 16 (no. 4); 89-95

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Mixed mean 19 points FMA upper extremity.
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised

Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot therapy (N = 13)
With hybrid FES exoskeleton system for hand rehabilitation. 12 sessions of 30 minutes for 2 weeks.

Standard arm therapy (N = 12)
10 sessions of 30 minutes for 2 weeks.

Outcomes

Study timepoints
- Baseline
- 2 week (Post-intervention)

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 2 week, N = 13	Standard arm therapy, Baseline, N = 12	Standard arm therapy, 2 week, N = 12
Arm function (Fugl-Meyer assessment) Scale range: 0-66. Change scores. Values reported in the Cochrane review used.	NR (NR)	3.23 (0.91)	NR (NR)	3.5 (0.79)

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 2 week, N = 13	Standard arm therapy, Baseline, N = 12	Standard arm therapy, 2 week, N = 12
Mean (SD)				
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale- hand function section) Scale range: 5-25. Change scores. Values reported in the Cochrane review used. Mean (SD)	NR (NR)	4.3 (0.85)	NR (NR)	3.5 (0.98)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale- hand function section) - Polarity - Higher values are better

Also reports BBT, FM score by distal and proximal limb.

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 2 week, N = 13	Standard arm therapy, Baseline, N = 12	Standard arm therapy, 2 week, N = 12
Withdrawals for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalsforanyreason-NoOfEvents-Robot therapy-Standard arm therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot therapy-Standard arm therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale-handfunctionsection)-MeanSD-Robot therapy-Standard arm therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Gueye, 2021

Bibliographic Reference	Gueye, T.; Dedkova, M.; Rogalewicz, V.; Grunerova-Lippertova, M.; Angerova, Y.; Early post-stroke rehabilitation for upper limb motor function using virtual reality and exoskeleton: equally efficient in older patients; Neurologia i Neurochirurgia Polska; 2021; vol. 55 (no. 1); 91-96

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	No additional information.
Study type	Randomised controlled trial (RCT)
Study location	Czech Republic
Study setting	Outpatient follow up
Study dates	January 2015 and June 2019.
Sources of funding	No additional information.
Inclusion criteria	First acute stroke with onset less than 30 days before the start of the therapy; ability to cooperate (as rated by the treating physician) and a post-stroke upper limb function deficit (FMA-UE 6-60 points).
Exclusion criteria	Severe cognitive impairment or severe sensoric aphasia; severe vision impairment diagnosed by an ophthalmologist, and the presence of any other neurological condition. MoCA scores were not used as an exclusion criteria.

Recruitment / selection of participants	People at the Stroke Rehabilitation Unit of the General University Hospital in Prague.
Intervention(s)	Robot-assisted arm therapy N=25 Virtual reality robot-assisted arm therapy using an Armeo Spring device and visual biofeedback from a screen in the form of games, completing different functional tasks as a part of their rehabilitation therapy. 45 minute sessions for 12 sessions over a three week period (4 sessions per week). Concomitant therapy: The programme consists of at least 3-4 hours of activity which includes one hour of physiotherapy twice a day, occupational therapy, therapies using passive or motor splints and moto operated/motor assisted/active movement training and individual or group therapy for speech and cognitive impairment.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear

Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information.
Comparator	Usual care N=25 An additional 45 minutes of physiotherapy for 12 sessions over a three week period (4 sessions per week). Concomitant therapy: The programme consists of at least 3-4 hours of activity which includes one hour of physiotherapy twice a day, occupational therapy, therapies using passive or motor splints and moto operated/motor assisted/active movement training and individual or group therapy for speech and cognitive impairment.
Number of participants	50
Duration of follow-up	Three weeks (end of intervention)
Indirectness	No additional information
Additional comments	No information on method of analysis. Appears to be completers only.

Study arms

Robot-assisted arm therapy (N = 25)
Virtual reality robot-assisted arm therapy using an Armeo Spring device and visual biofeedback from a screen in the form of games, completing different functional tasks as a part of their rehabilitation therapy. 45 minute sessions for 12 sessions over a three week period (4 sessions per week). Concomitant therapy: The programme consists of at least 3-4 hours of activity which includes one hour

of physiotherapy twice a day, occupational therapy, therapies using passive or motor splints and moto operated/motor assisted/active movement training and individual or group therapy for speech and cognitive impairment.

Usual care (N = 25)
An additional 45 minutes of physiotherapy for 12 sessions over a three week period (4 sessions per week). Concomitant therapy: The programme consists of at least 3-4 hours of activity which includes one hour of physiotherapy twice a day, occupational therapy, therapies using passive or motor splints and moto operated/motor assisted/active movement training and individual or group therapy for speech and cognitive impairment.

Characteristics

Arm-level characteristics

Characteristic	**Robot-assisted arm therapy (N = 25)**	**Usual care (N = 25)**
% Female Sample size	n = 11 ; % = 44	n = 10 ; % = 40
Mean age (SD) (years) Mean (SD)	66.56 (12.26)	68.12 (11.97)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm therapy (N = 25)	Usual care (N = 25)
Sample size		
Time after stroke (days) Mean (SD)	14.88 (6.45)	16.4 (7.25)

Outcomes

Study timepoints

- Baseline
- 3 week (Post-intervention)

Continuous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 25	Robot-assisted arm therapy, 3 week, N = 25	Usual care, Baseline, N = 25	Usual care, 3 week, N = 25
Activities of daily living (functional independence measure) Scale range: 0-126. Final values. Mean (SD)	89 (14.35)	110.8 (8.17)	82.8 (19.92)	104.9 (15.49)
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Final values. Mean (SD)	39 (14.54)	54.5 (10.06)	45.2 (15.52)	54.2 (13.93)

Activities of daily living (functional independence measure) - Polarity - Higher values are better

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot-assisted arm therapy, Baseline, N = 25	Robot-assisted arm therapy, 3 week, N = 25	Usual care, Baseline, N = 25	Usual care, 3 week, N = 25
Withdrawal for any reason 1 drop out from each study arm due to health problems unrelated to the intervention No of events	n = NA ; % = NA	n = 1 ; % = 4	n = NA ; % = NA	n = 1 ; % = 4

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot-assisted arm therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Helbok, 2010

Bibliographic Reference	Helbok, R.; Schoenherr, G.; Spiegel, M.; Sojer, M.; Brenneis, C.; Robot-assisted hand training (Amadeo) compared with conventional physiotherapy techniques in chronic ischemic stroke patients: a pilot study; DGNR Bremen, Nov; 2010

Study details

Secondary publication of another included study- see primary study for details	Helbok R. Robot-assisted hand training (AMADEO) compared with conventional physiotherapy techniques in chronic ischemic stroke patients: a pilot study. *Neurologie und Rehabilitation*. 6. Innsbruck, Austria: Hippocampus Verlag, 2010:281.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Hesse, 2014

Bibliographic Reference	Hesse, Stefan; Heß, Anke; Werner C, Cordula; Kabbert, Nadine; Buschfort, Rüdiger; Effect on arm function and cost of robot-assisted group therapy in subacute patients with stroke and a moderately to severely affected arm: a randomized controlled trial; Clinical rehabilitation; 2014; vol. 28 (no. 7); 637-647

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months) Mean 4.5 weeks in each group.
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week

Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot-assisted therapy (N = 25)
Robot-assisted group therapy for 30 minutes plus individual arm therapy for 30 minutes, each workday for 4 weeks.

Individual arm therapy (N = 25)
Individual arm therapy for 2 x 30 minutes each workday for 4 weeks.

Outcomes

Study timepoints
- Baseline
- 4 week (Post-intervention.)
- 3 month (Post-intervention)

1 ***Dichotomous outcome***

Outcome	Robot-assisted therapy, Baseline, N = 25	Robot-assisted therapy, 4 week, N = 25	Robot-assisted therapy, 3 month, N = 25	Individual arm therapy, Baseline, N = 25	Individual arm therapy, 4 week, N = 25	Individual arm therapy, 3 month, N = 25
Withdrawal for any reason 4 weeks: robot group: 1 refused to continue. 3 months: robot group: 1 not available, control group: 2 (1 refusal, 1 re-infarction). No of events	n = NA ; % = NA	n = 1 ; % = 4	n = 2 ; % = 8	n = NA ; % = NA	n = 0 ; % = 0	n = 2 ; % = 8
Adverse events Shoulder pain requiring NSAID prescription and/ or shoulder orthosis and/or physical therapy. No of events	n = NA ; % = NA	n = 4 ; % = 16	n = NR ; % = NR	n = NA ; % = NA	n = 3 ; % = 12	n = NR ; % = NR

2 ***Continuous outcome***

Outcome	Robot-assisted therapy, Baseline, N = 25	Robot-assisted therapy, 4 week, N = 25	Robot-assisted therapy, 3 month, N = 25	Individual arm therapy, Baseline, N = 25	Individual arm therapy, 4 week, N = 25	Individual arm therapy, 3 month, N = 25
Activities of daily living (barthel index) Change scores. Scale range 0-100 Mean (SD)	42 (14.5)	25.2 (11)	37.1 (16.9)	46.8 (19)	16 (15.7)	29.3 (21.4)
Arm function (Fugl-Meyer assessment)	14.6 (9.4)	11.1 (10.6)	16.8 (16)	16.5 (9.8)	14.6 (11.2)	20.2 (14.6)

Outcome	Robot-assisted therapy, Baseline, N = 25	Robot-assisted therapy, 4 week, N = 25	Robot-assisted therapy, 3 month, N = 25	Individual arm therapy, Baseline, N = 25	Individual arm therapy, 4 week, N = 25	Individual arm therapy, 3 month, N = 25
Change score. Scale range 0-66 Mean (SD)						
Arm strength (MRC) Change scores. Scale range 0-5 Mean (SD)	6.4 (6.7)	7.5 (7.1)	11.3 (10.1)	8.9 (7.8)	8.1 (6.4)	12.6 (12)
Spasticity (Ashworth MAS) Change scores. Scale range 0-45 Mean (SD)	2.6 (3.2)	0.1 (3.6)	0.6 (4.9)	2.3 (3.4)	0.2 (4.1)	0.6 (5.4)

Activities of daily living (barthel index) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm strength (MRC) - Polarity - Higher values are better
Spasticity (Ashworth MAS) - Polarity - Lower values are better
Also reports other functional outcomes: ARAT and Box and Block test.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Individual arm therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcome-Activitiesofdailyliving(barthelindex)-MeanSD-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Activitiesofdailyliving(barthelindex)-MeanSD-Robot-assisted therapy-Individual arm therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcome-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted therapy-Individual arm therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcome-Armstrength(MRC)-MeanSD-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armstrength(MRC)-MeanSD-Robot-assisted therapy-Individual arm therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcome-Spasticity(AshworthMAS)-MeanSD-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Spasticity(AshworthMAS)-MeanSD-Robot-assisted therapy-Individual arm therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcome-Adverseevents-NoOfEvents-Robot-assisted therapy-Individual arm therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Hesse, 2005

Bibliographic Reference	Hesse, Stefan; Werner, C.; Pohl, M.; Rueckriem, S.; Mehrholz, Jan; Lingnau, M. L.; Computerized arm training improves the motor control of the severely affected arm after stroke: a single-blinded randomized trial in two centers; Stroke; 2005; vol. 36 (no. 9); 1960-1966

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Not stated/unclear

Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	Not stated/unclear
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	Not stated/unclear
Subgroup 7: Level of supervision	Unsupervised 'therapist remained within shouting distance in case of problems'.
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot therapy (N = 22)

Electrical stimulation (N = 22)

Outcomes

Study timepoints

- Baseline
- 6 week

- 3 month

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 22	Robot therapy, 6 week, N = 22	Robot therapy, 3 month, N = 19	Electrical stimulation, Baseline, N = 22	Electrical stimulation, 6 week, N = 22	Electrical stimulation, 3 month, N = 20
Arm function (FMA UE) 0-66, final values Mean (SD)	7.9 (3.4)	24.6 (14.9)	30 (16.8)	7.3 (3.3)	10.4 (7.5)	16.6 (14.9)
Arm strength (Total MRC) 0-45, final value Mean (SD)	2.9 (2.6)	21.8 (10.5)	22.6 (11.1)	3.5 (3.3)	6.8 (8.3)	7.9 (9)
spasticity (total MAS) 0-25, final value Mean (SD)	1.5 (2.2)	1.7 (2.4)	1.4 (2.6)	0.8 (0.7)	1.8 (1.7)	1.8 (1.7)

Arm function (FMA UE) - Polarity - Higher values are better
Arm strength (Total MRC) - Polarity - Higher values are better
spasticity (total MAS) - Polarity - Lower values are better

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 22	Robot therapy, 6 week, N = 22	Robot therapy, 3 month, N = 22	Electrical stimulation, Baseline, N = 22	Electrical stimulation, 6 week, N = 22	Electrical stimulation, 3 month, N = 22
Withdrawal for any reason No of events	n = NA ; % = NA	n = 1 ; % = 5	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FMAUE)-MeanSD-Robot therapy-Electrical stimulation-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(TotalMRC)-MeanSD-Robot therapy-Electrical stimulation-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-spasticity(totalMAS)-MeanSD-Robot therapy-Electrical stimulation-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-spasticity(totalMAS)-MeanSD-Robot therapy-Electrical stimulation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Partially applicable *(not reported at over 6 months)*

Continuousoutcomes-Armstrength(TotalMRC)-MeanSD-Robot therapy-Electrical stimulation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Partially applicable *(not reported at over 6 months)*

Continuousoutcomes-Armfunction(FMAUE)-MeanSD-Robot therapy-Electrical stimulation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*

Section	Question	Answer
Overall bias and Directness	Overall Directness	Partially applicable *(not reported at over 6 months)*

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot therapy-Electrical stimulation-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to selection of reported result)*
Overall bias and Directness	Overall Directness	Directly applicable

Hollenstein, 2011

Bibliographic Reference	Hollenstein, C.; Cabri, C.; Additional therapy with computer-aided training system compared to occupational therapy arm group therapy; Neuroreha; 2011; vol. 3 (no. 1); 40-2

Study details

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Not stated/unclear
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

Study arms

Robot-mediated therapy (N = 7)
With the Armeo device 5 times a week for 30 minutes over 2 weeks (10 times).

Arm group programme (N = 6)
Without device delivered by an occupational therapist for the same time and frequency as the robot therapy group.

Outcomes

Study timepoints

- Baseline
- 2 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-mediated therapy, Baseline, N = 7	Robot-mediated therapy, 2 week, N = 7	Arm group programme, Baseline, N = 6	Arm group programme, 2 week, N = 6
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Continuous outcomes

Outcome	Robot-mediated therapy, Baseline, N = 7	Robot-mediated therapy, 2 week, N = 7	Arm group programme, Baseline, N = 6	Arm group programme, 2 week, N = 6
Arm function (Fugl-Meyer assessment) Change scores. Scale range 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	3.4 (3.9)	NR (NR)	3.7 (4.1)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Continuousoutcomes-rmfunction(Fugl-Meyerassessment)-MeanSD-Robot-mediated therapy-Arm group programme-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Insufficient information to determine- unclear risk in at least 2 domains.)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Arm group programme-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Insufficient information to determine- unclear risk in at least 2 domains.)*
Overall bias and Directness	Overall Directness	Directly applicable

Housman, 2009

Bibliographic Reference	Housman, Sarah J.; Scott, Kelly M.; Reinkensmeyer, David J.; A randomized controlled trial of gravity-supported, computer-enhanced arm exercise for individuals with severe hemiparesis; Neurorehabilitation and neural repair; 2009; vol. 23 (no. 5); 505-514

Study details

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Trial name / registration number	
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks 8-9 weeks
Subgroup 7: Level of supervision	Mixed The first 3 sessions were supervised; afterwards supervision was intermittent.

Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot-mediated therapy (N = 17)
With T-WREX device 3 times a week for 1 hour over 8-9 weeks. The first 3 sessions were supervised; afterwards supervision was intermittent.

Non-robot therapy (N = 17)
As above, but without the device.

Outcomes

Study timepoints
- Baseline
- 9 week ((8-9 weeks) post-intervention)
- 6 month (Post-intervention)

1 ***Dichotmous outcome***

Outcome	Robot-mediated therapy, Baseline, N = 17	Robot-mediated therapy, 9 week, N = 17	Robot-mediated therapy, 6 month, N = 14	Non-robot therapy , Baseline, N = 17	Non-robot therapy , 9 week, N = 17	Non-robot therapy , 6 month, N = 14
Withdrawal for any reason During treatment: robot group: 2 injured hemiparetic arm in daily life, control group: 1 onset of depression. Follow-up: robot group: 1 moved out of state, control group: 2 lost in follow-up (participated in confounding research). No of events	n = NA ; % = NA	n = 2 ; % = 11.7	n = 3 ; % = 17.7	n = NA ; % = NA	n = 1 ; % = 5.9	n = 3 ; % = 17.7

2 ***Continuous outcome***

Outcome	Robot-mediated therapy, Baseline, N = 17	Robot-mediated therapy, 9 week, N = 17	Robot-mediated therapy, 6 month, N = 14	Non-robot therapy , Baseline, N = 17	Non-robot therapy , 9 week, N = 17	Non-robot therapy , 6 month, N = 14
Activities of daily living (Motor activity log amount of use) Change scores. Scale range 0-5. Values as reported in Cochrane review. Mean (SD)	0.6 (0.4)	0.2 (0.4)	0.4 (0.7)	0.3 (0.3)	0.1 (0.3)	0.3 (0.4)
Arm function (Fugl-Meyer) Change scores. Scale range	21.7 (5.9)	3.3 (2.4)	3.6 (2.9)	18.1 (5)	2.2 (2.6)	1.5 (2.7)

Outcome	Robot-mediated therapy, Baseline, N = 17	Robot-mediated therapy, 9 week, N = 17	Robot-mediated therapy, 6 month, N = 14	Non-robot therapy , Baseline, N = 17	Non-robot therapy , 9 week, N = 17	Non-robot therapy , 6 month, N = 14
0-66. Values as reported in Cochrane review. Mean (SD)						
Arm muscle strength (grip strength, kg force) Change scores. Values as reported in Cochrane review. Mean (SD)	8.2 (4.1)	0.8 (3)	1.8 (4.8)	4.2 (3)	0.8 (2.3)	1.4 (2.2)

Activities of daily living (Motor activity log amount of use) - Polarity - Higher values are better
Arm function (Fugl-Meyer) - Polarity - Higher values are better
Arm muscle strength (grip strength, kg force) - Polarity - Higher values are better
Also reports rancho level, Rancho speed, MAL Quality of control movement and ROM deficit.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotmousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Non-robot therapy -t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotmousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-mediated therapy-Non-robot therapy -t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Activitiesofdailyliving(Motoractivitylogamountofuse)-MeanSD-Robot-mediated therapy-Non-robot therapy -t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Activitiesofdailyliving(Motoractivitylogamountofuse)-MeanSD-Robot-mediated therapy-Non-robot therapy -t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-Meyer)-MeanSD-Robot-mediated therapy-Non-robot therapy -t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-Meyer)-MeanSD-Robot-mediated therapy-Non-robot therapy -t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armmusclestrength(gripstrength,kgforce)-MeanSD-Robot-mediated therapy-Non-robot therapy -t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armmusclestrength(gripstrength,kgforce)-MeanSD-Robot-mediated therapy-Non-robot therapy -t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Hsieh, 2016

Bibliographic Reference	Hsieh, Yu-wei; Liing, Rong-jiuan; Lin, Keh-chung; Wu, Ching-yi; Liou, Tsan-hon; Lin, Jui-chi; Hung, Jen-wen; Sequencing bilateral robot-assisted arm therapy and constraint-induced therapy improves reach to press and trunk kinematics in patients with stroke; Journal of neuroengineering and rehabilitation; 2016; vol. 13 (no. 1); 1-9

Study details

Secondary publication of another included study- see primary study for details	Hsieh YW, Lin KC, Horng YS, Wu CY, Wu TC, Ku FL. Sequential combination of robot-assisted therapy and constraint-induced therapy in stroke rehabilitation: a randomized controlled trial. *Journal of Neurology* 2014;261(5):1037-45.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Hsieh, 2014

Bibliographic Reference	Hsieh, Yu-wei; Lin, Keh-chung; Horng, Yi-shiung; Wu, Ching-yi; Wu, Tai-chieh; Ku, Fang-ling; Sequential combination of robot-assisted therapy and constraint-induced therapy in stroke rehabilitation: a randomized controlled trial; Journal of neurology; 2014; vol. 261 (no. 5); 1037-1045

Study details

Secondary publication of another included study- see primary study for details	No additional information.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Hsieh Y-W, Liing R-J, Lin K-C, Wu C-Y, Liou T-H, Lin J-C, et al. Sequencing bilateral robot-assisted arm therapy and constraint-induced therapy improves reach to press and trunk kinematics in patients with stroke. *Journal of NeuroEngineering & Rehabilitation* 2016;13:1-9. [1743-0003]
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement	Mixed

delivered by robotic device	

Study arms

Robot assisted therapy (N = 32)
Group 1: RT + CIT group (robot-assisted arm therapy (Bi-Manu-Track) + constraint-induced therapy. Group 2: RT group (robot-assisted arm therapy (Bi-Manu-Track)) Groups were combined for analysis.

Conventional therapy (N = 16)
Received a therapist-mediated intervention using conventional occupational therapy techniques, including neurodevelopmental techniques, functional task practice, fine motor training, arm exercises or gross motor training, and muscle strengthening, Participants in each group received 20 training sessions of 90 to 105 min/day, 5 days/ week for 4 weeks.

Outcomes

Study timepoints
- Baseline
- 4 week (Post-intervention)

Dichotomous outcome

Outcome	Robot assisted therapy, Baseline, N = 32	Robot assisted therapy, 4 week, N = 32	Conventional therapy, Baseline, N = 16	Conventional therapy, 4 week, N = 16
Withdrawal for any reason	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Robot assisted therapy, Baseline, N = 32	Robot assisted therapy, 4 week, N = 32	Conventional therapy, Baseline, N = 16	Conventional therapy, 4 week, N = 16
No of events				

Continuous outcome

Outcome	Robot assisted therapy, Baseline, N = 32	Robot assisted therapy, 4 week, N = 32	Conventional therapy, Baseline, N = 16	Conventional therapy, 4 week, N = 16
Arm function (Fugl-Meyer assessment)-total Change scores. Scale range 0-66. Values as reported in Cochrane review Mean (SD)	NR (NR)	7.3 (5.5)	NR (NR)	3.8 (5)

Arm function (Fugl-Meyer assessment)-total - Polarity - Higher values are better

Also reports distal and proximal FM, WMFT, MAL. Reported baseline total FM values: RT+dCIT: 32.19 (7.2), RT: 35.69 (9.62) Post-treatment total FM values: RT+dCIT: 40.69 (8.58), RT: 41.81 (9.4)

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Fugl-Meyerassessment)-total-MeanSD-Robot assisted therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot assisted therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Hsieh, 2011

Bibliographic Reference	Hsieh, Yu-wei; Wu, Ching-yi; Liao, Wan-wen; Lin, Keh-chung; Wu, Kuen-yuh; Lee, Chia-yi; Effects of treatment intensity in upper limb robot-assisted therapy for chronic stroke: a pilot randomized controlled trial; Neurorehabilitation and neural repair; 2011; vol. 25 (no. 6); 503-511

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot assisted therapy (N = 12)
Group 1: Higher intensity RT group: Bi-Manu Track used in this study for 20 training sessions for 90 to 105 minutes, 5days per week for 4 weeks. After the RT, participants received 15-20 minutes of functional activities training. Group 2: Lower-intensity RT group: with the Bi-Manu Track the participants received a different frequency of RT; afterwards receiving the same treatment of functional abilities as the high intensity group. Groups were combined for analysis.

Conventional rehabilitation (N = 6)
Participants received a structured protocol using conventional occupational therapy techniques.

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention.)

Dichotomous outcome

Outcome	Robot assisted therapy, Baseline, N = 12	Robot assisted therapy, 4 week, N = 12	Conventional rehabilitation, Baseline, N = 6	Conventional rehabilitation, 4 week, N = 6
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot assisted therapy, Baseline, N = 12	Robot assisted therapy, 4 week, N = 12	Conventional rehabilitation, Baseline, N = 6	Conventional rehabilitation, 4 week, N = 6
Arm function (Fugl-Meyer scale-upper extremity) Final values. Scale range 0-33. Values as reported in Cochrane review Mean (SD)	NR (NR)	4.2 (5.9)	NR (NR)	2.8 (7.4)

Outcome	Robot assisted therapy, Baseline, N = 12	Robot assisted therapy, 4 week, N = 12	Conventional rehabilitation, Baseline, N = 6	Conventional rehabilitation, 4 week, N = 6
Arm muscle strength (MRC) Final values. Scale range 0-5. Values as reported in Cochrane review Mean (SD)	NR (NR)	3.5 (0.5)	NR (NR)	3.3 (0.7)
Activities of dailty living (Motor activity log) Final values. Scale range unclear. Values as reported in Cochrane review. Mean (SD)	NR (NR)	0.1 (0.2)	NR (NR)	0.1 (0.3)

Arm function (Fugl-Meyer scale- upper extremity) - Polarity - Higher values are better
Arm muscle strength (MRC) - Polarity - Higher values are better
Activities of dailty living (Motor activity log) - Polarity - Higher values are better
Also reports MFSI and ABILHAND

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailtyliving(Motoractivitylog)-MeanSD-Robot assisted therapy-Conventional rehabilitation-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerscale-upperextremity)-MeanSD-Robot assisted therapy-Conventional rehabilitation-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MRC)-MeanSD-Robot assisted therapy-Conventional rehabilitation-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot assisted therapy-Conventional rehabilitation-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Hsu, 2019

Bibliographic Reference	Hsu, H. Y.; Chiu, H. Y.; Kuan, T. S.; Tsai, C. L.; Su, F. C.; Kuo, L. C.; Robotic-assisted therapy with bilateral practice improves task and motor performance in the upper extremities of chronic stroke patients: A randomised controlled trial; Australian Occupational Therapy Journal; 2019; vol. 66 (no. 5); 637-647

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	Clinicaltrials.gov = NCT03847103.
Study type	Randomised controlled trial (RCT)
Study location	Taiwan
Study setting	Outpatient follow up
Study dates	No additional information
Sources of funding	This work was supported by Chi Mei Medical Center and National Cheng Kung University under grant #CMNCKU10304. This work was also financially supported by the Medical Device Innovation Center, National Cheng Kung University from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan.
Inclusion criteria	Diagnosis of stroke with unilateral cerebral infarction of haemorrhage whose time post-stroke was more than six months; exhibit no evidence of any other cerebral pathology in study screening CT scan; have an eligibility screening score on the Fugl-Meyer upper extremity motor assessment ranging from 23-53 corresponding with poor to notable arm-hand capacity; no reported pre-stroke difficulties in verbal communication; no impairment revealed in eligibility screening tests on the mini-mental state examination score above 24 and Lowenstein occupational therapy cognitive assessment item scores at or above 8 for visual perception, 6 for spatial perceptions, 6 for praxis and 14 for visuomotor organisation; pre-stroke right-handedness.

Exclusion criteria	Not meeting the inclusion criteria; CT showing multiple cerebral infarctions or haemorrhage; with Wernicke's aphasia or global aphasia leading to difficulty with following written or spoken multi-step instruction.
Recruitment / selection of participants	No additional information.
Intervention(s)	Robot-assisted arm therapy N=22 Robot-aided rehabilitation with bilateral practice to improve upper limb motor and task performance. Bi-Manu-Track device enabling practice of two different movement cycles using an end-effector based machine to provide bimanual passive and active practice of the forearm and wrist muscles. The exercise included passive-passive, active-passive and active-active training. The repetitive task training interventions took 40 minutes with a minimum of 400 robot-facilitated repetitions of the wrist flexion/extension as well as 400 reptitions of forearm supination/pronation movement, three times per week for four weeks. Concomitant therapy: All people received a 10-minute per-protocol sensorimotor stimulation session prior to the interventions as part of usual care.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week

Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information
Comparator	Usual care N=21 40 minutes of therapist-facilitated task-specific training for the affected limb. The task-specific training followed the same number of repetitions per task and the maximum of three tasks from the task menu as well as implementation of a consistent movement pattern for the task. Session dose consisted of 180 repetitions of three target tasks for a session time of 40 minutes done three times per week for 4 weeks. Concomitant therapy: All people received a 10-minute per-protocol sensorimotor stimulation session prior to the interventions as part of usual care.
Number of participants	43
Duration of follow-up	4 weeks (end of intervention) and 16 weeks (this time point will be included but downgraded for indirectness for being less than 6 months).
Indirectness	Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.
Additional comments	ITT no drop outs.

1

Study arms

Robot-assisted arm therapy (N = 22)
Robot-aided rehabilitation with bilateral practice to improve upper limb motor and task performance. Bi-Manu-Track device enabling practice of two different movement cycles using an end-effector based machine to provide bimanual passive and active practice of the forearm and wrist muscles. The exercise included passive-passive, active-passive and active-active training. The repetitive task training interventions took 40 minutes with a minimum of 400 robot-facilitated repetitions of the wrist flexion/extension as well as 400 reptitions of forearm supination/pronation movement, three times per week for four weeks. Concomitant therapy: All people received a 10-minute per-protocol sensorimotor stimulation session prior to the interventions as part of usual care.

Usual care (N = 21)
40 minutes of therapist-facilitated task-specific training for the affected limb. The task-specific training followed the same number of repetitions per task and the maximum of three tasks from the task menu as well as implementation of a consistent movement pattern for the task. Session dose consisted of 180 repetitions of three target tasks for a session time of 40 minutes done three times per week for 4 weeks. Concomitant therapy: All people received a 10-minute per-protocol sensorimotor stimulation session prior to the interventions as part of usual care.

Characteristics

Arm-level characteristics

Characteristic	**Robot-assisted arm therapy (N = 22)**	**Usual care (N = 21)**
% Female Sample size	n = 11 ; % = 50	n = 12 ; % = 57
Mean age (SD) (years) Mean (SD)	53.1 (13.9)	52.6 (12.5)

Characteristic	Robot-assisted arm therapy (N = 22)	Usual care (N = 21)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (Months) Mean (SD)	13.7 (8.6)	14.7 (13.2)

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention)
- 16 week (≥6 months - outcomes at this time point will be downgraded for indirectness)

Continuous outcome

Outcome	Robot-assisted arm therapy, Baseline, N = 22	Robot-assisted arm therapy, 4 week, N = 22	Robot-assisted arm therapy, 16 week, N = 22	Usual care, Baseline, N = 21	Usual care, 4 week, N = 21	Usual care, 16 week, N = 21
Arm function (Fugl-Meyer Assessment - Total upper limb motor score) Scale range: 0-66. Final values. Mean (SD)	38.6 (12.4)	43.1 (13)	45.2 (13.6)	41.9 (14.9)	44.1 (15.9)	44.9 (14.5)

Arm function (Fugl-Meyer Assessment - Total upper limb motor score) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 22	Robot-assisted arm therapy, 4 week, N = 22	Robot-assisted arm therapy, 16 week, N = 22	Usual care, Baseline, N = 21	Usual care, 4 week, N = 21	Usual care, 16 week, N = 21
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0
Adverse events - Other reported adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - Other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Fugl-MeyerAssessment-Totalupperlimbmotorscore)-MeanSD-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-MeyerAssessment-Totalupperlimbmotorscore)-MeanSD-Robot-assisted arm therapy-Usual care-t16

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t16

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Dichotomousoutcomes-Adverseevents-Otherreportedadverseevents-NoOfEvents-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-Otherreportedadverseevents-NoOfEvents-Robot-assisted arm therapy-Usual care-t16

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Hsu, 2021

Bibliographic Reference	Hsu, H. Y.; Yang, K. C.; Yeh, C. H.; Lin, Y. C.; Lin, K. R.; Su, F. C.; Kuo, L. C.; A Tenodesis-Induced-Grip exoskeleton robot (TIGER) for assisting upper extremity functions in stroke patients: a randomized control study; Disability & Rehabilitation; 2021; 1-9

Study details

Secondary publication of another included study- see primary study for details	No additional information
Other publications associated with this study included in review	No additional information
Trial name / registration number	Clinicaltrials.gov = NCT03713476
Study type	Randomised controlled trial (RCT)
Study location	Taiwan
Study setting	Outpatient follow up
Study dates	No additional information
Sources of funding	Financially supported by the Medical Device Innovation Center, National Cheng Kung University, from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education in Taiwan. This project was supported in part by the Ministry of Science and Technology, Taiwan, under Grant MOST 108-2745-8-006-009 and in part by the National Cheng Kung University Hospital, Tainan, Taiwan under Grant NCKUH 10708003.

Inclusion criteria	Chronic stroke patients with unilateral cerebral infarction of haemorrhage whose disease duration was more than 6 months following a stroke; a score on the Fugl-Meyer upper extremity motor assessment ranging from 15 to 55 corresponding to severe-moderate to moderate-mild impairment level of upper extremity; a score on the mini-mental state examination no lower than 24; first-ever stroke.
Exclusion criteria	People with shoulder-hand syndrome; wrist pain; notable joint contracture; Wernicke's aphasia or global aphasia leading to difficulty with following instructions.
Recruitment / selection of participants	Convenience sample of people referred from the Department of Physical Medicine and Rehabilitation of a medical centre in southern Taiwan
Intervention(s)	Robot-assisted arm therapy N=17 An additional 20-minutes of robot-assisted arm training using TIGER (Tenodesis-induced-grip exoskeleton robot) with two working modes: continuous passive mode and a functional mode that was built into the controller (active-assisted). Designed to train the distal limb. Two sessions of training a week for 9 weeks. Concomitant therapy: All people received 20-minutes of regular task-specific motor training.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week

Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.
Comparator	Usual care N=17 An additional 20-minutes of task-specific motor training through regular occupational therapy. Concomitant therapy: All people received 20-minutes of regular task-specific motor training.
Number of participants	34
Duration of follow-up	9 weeks (post-intervention), 12 weeks after post-intervention (21 weeks) - the latter time point will be included as ≥6 months but downgraded for indirectness as the value is less than 6 months).
Indirectness	Outcome indirectness - Outcomes at 21 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.
Additional comments	No additional information. Appears to be completers only.

1

Study arms

Robot-assisted arm therapy (N = 17)
An additional 20-minutes of robot-assisted arm training using TIGER (Tenodesis-induced-grip exoskeleton robot) with two working modes: continuous passive mode and a functional mode that was built into the controller (active-assisted). Designed to train the distal limb. Two sessions of training a week for 9 weeks. Concomitant therapy: All people received 20-minutes of regular task-specific motor training.

Usual care (N = 17)
An additional 20-minutes of task-specific motor training through regular occupational therapy. Concomitant therapy: All people received 20-minutes of regular task-specific motor training.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm therapy (N = 17)	Usual care (N = 17)
% Female Sample size	n = NR ; % = NR	n = NR ; % = NR
Mean age (SD) (years) Mean (SD)	55.5 (13.4)	56.3 (16.5)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm therapy (N = 17)	Usual care (N = 17)
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (Months) Mean (SD)	23.6 (15.9)	36.3 (29.5)

Outcomes

Study timepoints

- Baseline
- 9 week (Post-intervention)
- 21 week (≥6 months - outcomes at this time point will be downgraded for indirectness)

Continuous outcome

Outcome	Robot-assisted arm therapy, Baseline, N = 17	Robot-assisted arm therapy, 9 week, N = 17	Robot-assisted arm therapy, 21 week, N = 17	Usual care, Baseline, N = 15	Usual care, 9 week, N = 15	Usual care, 21 week, N = 15
Arm function (Fugl-Meyer Assessment Upper Extremity total motor score) Scale range: 0-66. Final values. Mean (SD)	35.1 (14.3)	42.1 (14.4)	44.3 (13.7)	26.2 (12.3)	27.6 (12.6)	26.7 (13.2)

Outcome	Robot-assisted arm therapy, Baseline, N = 17	Robot-assisted arm therapy, 9 week, N = 17	Robot-assisted arm therapy, 21 week, N = 17	Usual care, Baseline, N = 15	Usual care, 9 week, N = 15	Usual care, 21 week, N = 15
Spasticity (modified Ashworth Scale wrist) Scale range: 0-4. Final values. Mean (SD)	1.06 (0.77)	0.94 (0.7)	0.85 (0.7)	1.53 (0.7)	1.43 (0.56)	1.3 (0.72)

1 Arm function (Fugl-Meyer Assessment Upper Extremity total motor score) - Polarity - Higher values are better
2 Spasticity (modified Ashworth Scale wrist) - Polarity - Lower values are better

3 ***Dichotomous outcomes***

Outcome	Robot-assisted arm therapy, Baseline, N = 17	Robot-assisted arm therapy, 9 week, N = 17	Robot-assisted arm therapy, 21 week, N = 17	Usual care, Baseline, N = 17	Usual care, 9 week, N = 17	Usual care, 21 week, N = 17
Withdrawal for any reason Control: 1 discontinued for personal issues, 1 lost to follow-up due to being unwilling to participate in follow-up assessments No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 2 ; % = 12	n = 2 ; % = 12
Adverse events - injuries and pain No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0

4 Withdrawal for any reason - Polarity - Lower values are better
5 Adverse events - injuries and pain - Polarity - Lower values are better

6

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Fugl-MeyerAssessmentUpperExtremitytotalmotorscore)-MeanSD-Robot-assisted arm therapy-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-MeyerAssessmentUpperExtremitytotalmotorscore)-MeanSD-Robot-assisted arm therapy-Usual care-t21

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 21 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Continuousoutcome-Spasticity(modifiedAshworthScalewrist)-MeanSD-Robot-assisted arm therapy-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Spasticity(modifiedAshworthScalewrist)-MeanSD-Robot-assisted arm therapy-Usual care-t21

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 21 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t21

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 21 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Dichotomousoutcomes-Adverseevents-injuriesandpain-NoOfEvents-Robot-assisted arm therapy-Usual care-t9

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-injuriesandpain-NoOfEvents-Robot-assisted arm therapy-Usual care-t21

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 21 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Hung, 2022

Bibliographic Reference	Hung, JW; Yen, CL; Chang, KC; Chiang, WC; Chuang, IC; Pong, YP; Wu, WC; Wu, CY; A Pilot Randomized Controlled Trial of Botulinum Toxin Treatment Combined with Robot-Assisted Therapy, Mirror Therapy, or Active Control Treatment in Patients with Spasticity Following Stroke; Toxins; 2022; vol. 14 (no. 6)

Study details

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	No additional information.
Trial name / registration number	No additional information.
Study type	Randomised controlled trial (RCT)
Study location	Taiwan.
Study setting	Outpatient follow up.
Study dates	No additional information.
Sources of funding	This work was supported by the Ministry of Science and Technology in Taiwan under 105-2314-B-182A-085, 106-2314-B-182A-121 and 109-2314-B-192-027-MY3; Chang Gung Memorial Hospital under BMRP553, BMRPG8E0931, MRPD1I-0031 and CMRPD1M0041; National Health Research Institutes under NHRI-EX111-11105PI.
Inclusion criteria	Unilateral stroke for at least 6 months duration; Modified Ashworth Scale >1 over the elbow flexor, forearm pronator, wrist flexor and/or finger flexor muscles; upper extremity Fugl-Meyer Assessment score of 17 to 56; Mini-Mental State Exam at least 21.
Exclusion criteria	Pregnancy; bilateral hemispheric or cerebellar lesions; visual field deficits or hemineglect; any contraindications for botulinum toxin; prior botulinum toxin treatment within 4 months of enrollment; joint contracture over the upper extremities; other orthopaedic or neurological diseases that would prevent adherence to the rehabilitation protocol.
Recruitment / selection of participants	People were recruited from the rehabilitation department of a medical center.
Intervention(s)	Robot arm training N=13 75 minutes of training, 3 times weekly for 8 consecutive weeks. Robot arm training using the Bi-Manu-Track robotic arm training system allowing for three training modes: passive-passive, active-passive and active-active. For each movement, the participants practiced 200 repetitions in mode 1, 750 repetitions in mode 2 and 50 to 200 repetitions in mode 3. The

	feedback on actions or force they exerted during practice was provided. Following this 45 minute period of training, people received an additional 30 minutes of practice in functional activities to facilitate transferring the acquired movements to daily activities. The selected functional tasks involved forearm pronation-supination or wrist flexion-extension movements, such as twisting a towel or bouncing a ball. Concomitant therapy: All people received an injection of botulinum toxin type A (50 U/mL diluted in 0.9% saline injected into the target muscle confirmed by ultrasound). Concurrent use of muscle relaxants, antispastic agents and drugs having muscle relaxant properties was maintained at constant dosages throughout the study. All other routine rehabilitation that did not involve upper extremity training proceeded as usual.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

Population subgroups	No additional information.
Comparator	Any other intervention (Mirror therapy and usual care) N=24 Two arms pooled together, both 75 minutes of training, 3 times weekly for 8 consecutive weeks. 1) Mirror therapy for 45 minutes of training per session. A mirror box was placed beside the unaffected hand to block the view of the affected hand. People were instructed to focus on the unaffected hand as if it were the affected hand and to perform exercises bilaterally and symmetrically as much as possible. The activities included: transitive movements (such as fine motor tasks of squeezing sponges, placing pegs in holes, flipping a card); gross motor tasks (reaching out to touch a switch or keyboard); intransitive movements (including the distal movement of the wrist, repetitive extension-flexion, or finger opponent, and the proximal part movement of forearm pronation/supination). Following this 45 minute period of training, people received an additional 30 minutes of practice in functional activities to facilitate transferring the acquired movements to daily activities. The selected functional tasks involved forearm pronation-supination or wrist flexion-extension movements, such as twisting a towel or bouncing a ball. 2) Usual care, 45 minutes of conventional task-oriented approach with bilateral symmetric movement training. The movement training involved grasping, manipulating and picking up and placing objects. After this people took part in the same 30 minutes of functional practice as the other groups. Concomitant therapy: All people received an injection of botulinum toxin type A (50 U/mL diluted in 0.9% saline injected into the target muscle confirmed by ultrasound). Concurrent use of muscle relaxants, antispastic agents and drugs having muscle relaxant properties was maintained at constant dosages throughout the study. All other routine rehabilitation that did not involve upper extremity training proceeded as usual.
Number of participants	36
Duration of follow-up	8 weeks (end of treatment) and 5 months (end of treatment + 3 months - this is less than the 6 months required for the mirror therapy review, but is the latest possible follow up required for the robot arm therapy review so will be extracted but not used for the mirror therapy review).
Indirectness	Outcome indirectness - time point >6 months (as the outcome is at less than 6 months)
Additional comments	All people randomised were included in the analysis (ITT no dropouts).

1

Study arms

Robot arm training (N = 13)

75 minutes of training, 3 times weekly for 8 consecutive weeks. Robot arm training using the Bi-Manu-Track robotic arm training system allowing for three training modes: passive-passive, active-passive and active-active. For each movement, the participants practiced 200 repetitions in mode 1, 750 repetitions in mode 2 and 50 to 200 repetitions in mode 3. The feedback on actions or force they exerted during practice was provided. Following this 45 minute period of training, people received an additional 30 minutes of practice in functional activities to facilitate transferring the acquired movements to daily activities. The selected functional tasks involved forearm pronation-supination or wrist flexion-extension movements, such as twisting a towel or bouncing a ball. Concomitant therapy: All people received an injection of botulinum toxin type A (50 U/mL diluted in 0.9% saline injected into the target muscle confirmed by ultrasound). Concurrent use of muscle relaxants, antispastic agents and drugs having muscle relaxant properties was maintained at constant dosages throughout the study. All other routine rehabilitation that did not involve upper extremity training proceeded as usual.

Any other intervention (Mirror therapy and usual care) (N = 24)

Two arms pooled together, both 75 minutes of training, 3 times weekly for 8 consecutive weeks. 1) Mirror therapy for 45 minutes of training per session. A mirror box was placed beside the unaffected hand to block the view of the affected hand. People were instructed to focus on the unaffected hand as if it were the affected hand and to perform exercises bilaterally and symmetrically as much as possible. The activities included: transitive movements (such as fine motor tasks of squeezing sponges, placing pegs in holes, flipping a card); gross motor tasks (reaching out to touch a switch or keyboard); intransitive movements (including the distal movement of the wrist, repetitive extension-flexion, or finger opponent, and the proximal part movement of forearm pronation/supination). Following this 45 minute period of training, people received an additional 30 minutes of practice in functional activities to facilitate transferring the acquired movements to daily activities. The selected functional tasks involved forearm pronation-supination or wrist flexion-extension movements, such as twisting a towel or bouncing a ball. 2) Usual care, 45 minutes of conventional task-oriented approach with bilateral symmetric movement training. The movement training involved grasping, manipulating and picking up and placing objects. After this people took part in the same 30 minutes of functional practice as the other groups. Concomitant therapy: All people received an injection of botulinum toxin type A (50 U/mL diluted in 0.9% saline injected into the target muscle confirmed by ultrasound). Concurrent use of muscle relaxants, antispastic agents and drugs having muscle relaxant properties was maintained at constant dosages throughout the study. All other routine rehabilitation that did not involve upper extremity training proceeded as usual.

1 **Characteristics**

2 ***Arm-level characteristics***

Characteristic	Robot arm training (N = 13)	Any other intervention (Mirror therapy and usual care) (N = 24)
% Female Sample size	n = 3 ; % = 23	n = 10 ; % = 42
Mean age (SD) (years) Mean (SD)	47.68 (12.79)	47.03 (10.8)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Mean (SD)	NR (NR)	NR (NR)
Time after stroke (Months) Mean (SD)	33.38 (22.71)	35.63 (21.53)

3

4 **Outcomes**

5 ***Study timepoints***

6 • Baseline
7 • 8 week (End of intervention)
8 • 5 month (>6 months (downgrade for indirectness))

Continuous outcomes

Outcome	Robot arm training, Baseline, N = 13	Robot arm training, 8 week, N = 13	Robot arm training, 5 month, N = 13	Any other intervention (Mirror therapy and usual care), Baseline, N = 24	Any other intervention (Mirror therapy and usual care), 8 week, N = 24	Any other intervention (Mirror therapy and usual care), 5 month, N = 24
Arm function (Fugl Meyer Assessment - Upper Extremity) Scale range: 0-66. Final values. Mirror therapy 8 weeks: 35.9 (6.48). Mirror therapy 5 months: 34.9 (8.49). Usual care 8 weeks: 32.9 (12.0). Usual care 5 months: 33.7 (11.0). Mean (SD)	32.92 (7.12)	36.46 (8.88)	34.92 (7.25)	31.17 (9.79)	34.41 (9.8)	34.33 (9.84)
Spasticity (modified Ashworth scale) Scale range: 0-4. Final values. Summed values for the elbow flexor, forearm pronator, wrist flexor and finger PIP flexor. For full details see study. Mean (SD)	1.75 (0.7)	1.16 (0.91)	1.49 (0.99)	1.69 (0.88)	1.29 (0.9)	1.54 (0.8)

Arm function (Fugl Meyer Assessment - Upper Extremity) - Polarity - Higher values are better

Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Dichotomous outcome

Outcome	Robot arm training, Baseline, N = 13	Robot arm training, 8 week, N = 13	Robot arm training, 5 month, N = 13	Any other intervention (Mirror therapy and usual care), Baseline, N = 24	Any other intervention (Mirror therapy and usual care), 8 week, N = 24	Any other intervention (Mirror therapy and usual care), 5 month, N = 24
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerAssessment-UpperExtremity)-MeanSD-Robot arm training-Any other intervention (Mirror therapy and usual care)-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot arm training-Any other intervention (Mirror therapy and usual care)-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot arm training-Any other intervention (Mirror therapy and usual care)-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessment-UpperExtremity)-MeanSD-Robot arm training-Any other intervention (Mirror therapy and usual care)-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - follow up period <6 months)*

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot arm training-Any other intervention (Mirror therapy and usual care)-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - follow up period <6 months)*

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot arm training-Any other intervention (Mirror therapy and usual care)-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - follow up period <6 months)*

Hwang, 2012

Bibliographic Reference	Hwang, Chang Ho; Seong, Jin Wan; Son, Dae-Sik; Individual finger synchronized robot-assisted hand rehabilitation in subacute to chronic stroke: a prospective randomized clinical trial of efficacy; Clinical Rehabilitation; 2012; vol. 26 (no. 8); 696-704

Study details

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Mixed Average 6.5 (5.3) months after stroke.
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

1

Study arms

Robot-assisted intervention (N = 9)
4 weeks (20 sessions) of active robot-assisted intervention (full-term intervention) group. The robot-assisted therapy included individual finger synchronisation (Amadeo, Tyromotion, Austria).

Early passive therapy (N = 5)
2weeks (10 sessions) of early passive therapy, followed by 2 weeks (10 sessions) of active robot-assisted intervention (the half term intervention) group. Data from the first 2 weeks of intervention were used.

Outcomes

Study timepoints
- Baseline
- 2 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-assisted intervention, Baseline, N = 9	Robot-assisted intervention, 2 week, N = 9	Early passive therapy, Baseline, N = 8	Early passive therapy, 2 week, N = 8
Withdrawal for any reason As reported in Cochrane review. However, paper reports 2 drop outs in control group (1 did not receive allocated intervention and 1 was lost to follow-up within first 2 week period) No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot-assisted intervention, Baseline, N = 9	Robot-assisted intervention, 2 week, N = 9	Early passive therapy, Baseline, N = 8	Early passive therapy, 2 week, N = 6
Arm function (Fugl-Meyer) Change scores. FM scale used unclear. Values as reported in Cochrane review Mean (SD)	NR (NR)	3.5 (4.19)	NR (NR)	1.3 (4.32)
Arm muscle strength (scale unclear) Change scores. Values as reported in Cochrane review. Mean (SD)	NR (NR)	1.7 (7.04)	NR (NR)	1.3 (6.3)
Spasticity (Ashworth scale)- wrist Change scores. Scale range ?0-5 Mean (SD)	0.9 (0.3)	0.8 (0.9)	0.5 (0.2)	0.5 (0.5)
Spasticity (Ashworth scale)- elbow Change scores. Scale range ?0-5 Mean (SD)	1.2 (0.1)	1.2 (0.4)	1.4 (0.4)	1.3 (1)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale - hand motor subscale) Change scores. Scale range 12-60 Mean (SD)	38.8 (6)	47.6 (7.5)	48.7 (1.7)	47 (6.2)

Arm function (Fugl-Meyer) - Polarity - Higher values are better

Arm muscle strength (scale unclear) - Polarity - Higher values are better

Spasticity (Ashworth scale)- wrist - Polarity - Lower values are better

Spasticity (Ashworth scale)- elbow - Polarity - Lower values are better
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale - hand motor subscale) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Spasticity(Ashworthscale)-elbow-MeanSD-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyer)-MeanSD-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(scaleunclear)-MeanSD-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-wrist-MeanSD-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-handmotorsubscale)-MeanSD-Robot-assisted intervention-Early passive therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Iwamoto, 2019

Bibliographic Reference	Iwamoto, Y.; Imura, T.; Suzukawa, T.; Fukuyama, H.; Ishii, T.; Taki, S.; Imada, N.; Shibukawa, M.; Inagawa, T.; Araki, H.; Araki, O.; Combination of Exoskeletal Upper Limb Robot and Occupational Therapy Improve Activities of Daily Living Function in Acute Stroke Patients; Journal of Stroke & Cerebrovascular Diseases; 2019; vol. 28 (no. 7); 2018-2025

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	NR
Study location	Japan
Study setting	Inpatients rehabilitation department of neurosurgical hospital
Study dates	NR
Sources of funding	NR
Inclusion criteria	Inclusion criteria were (1) first-time stroke, (2) Brunnstrom recovery stage (Br-stage) II to IV, and (3) study participant within 2 weeks after stroke onset.
Exclusion criteria	Patients were excluded if (1) the surface electrode could not be attached to the skin due to cutaneous disease or (2) they were not able to follow instructions.
Recruitment / selection of participants	NR
Intervention(s)	Hybrid Assistive Limb (HAL-SJ) HAL-SJ was attached to the elbow joint, and the patients were supported flexion and extension movement of the elbow joint. A surface electrode was attached to the patient on the muscle belly of the biceps brachii and triceps brachii muscles to record the EMG. Configuration parameters of HAL-SJ included assist gain (intensity

	of assist) and assist balance (balance between flexor muscle assist and extensor muscle assist), and the parameters were individually designed by the occupational therapists depending on the patient's symptoms. During A, the patients underwent robotic rehabilitation using HAL-SJ for 40 minutes per day and performed at least 200 movements (flexion and extension) of the elbow joint. Concomitant therapy -The total time of combination therapy during A and occupational therapy during B was equivalent. In the current Japanese medical system, the medical doctor prescribes a rehabilitation programme, and rehabilitation therapists (occupational therapist, physiotherapist, and speech therapist) design individually tailored exercise programmes for acute stroke patients for up to 3 hours per day.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Population subgroups	NR
Comparator	Occupational therapy included passive or active mobilization, task-specific training, and ADL training such as eating, grooming, dressing (upper and lower body), toileting, and bathing. Occupational therapy focusing on the patient's ADL function and the distribution of each programme was individually designed depending on the patient's symptoms.
Number of participants	12
Duration of follow-up	end of intervention
Indirectness	NR
Additional comments	NR

Study arms

Robotic Rehabilitation (N = 6)

Conventional therapy (N = 6)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 12)**
Ethnicity Nominal	NR

Characteristic	Study (N = 12)
Comorbidities Nominal	NR
Severity Nominal	NR
Time after stroke Nominal	NR

Arm-level characteristics

Characteristic	Robotic Rehabilitation (N = 6)	Conventional therapy (N = 6)
% Female Nominal	16.7	50
Mean age (SD) Mean (SD)	62.33 (10.23)	59.67 (24.56)

Outcomes

Study timepoints

- Baseline
- 4 week

Continuous outcomes

Outcome	Robotic Rehabilitation, Baseline, N = 6	Robotic Rehabilitation, 4 week, N = 6	Conventional therapy, Baseline, N = 6	Conventional therapy, 4 week, N = 5
Acitvities of daily living (Barthel Index) 0-100, change score Mean (SD)	46.67 (21.6)	9.17 (5.97)	42.5 (19.69)	2.5 (4.52)
Arm strength (Motricity Index) change score Mean (SD)	42.83 (10.32)	2.75 (7.19)	49.5 (15.11)	1.67 (4.66)

Acitvities of daily living (Barthel Index) - Polarity - Higher values are better

Arm strength (Motricity Index) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Continuousoutcomes-Acitvitiesofdailyliving(BarthelIndex)-MeanSD-Robotic Rehabilitation-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Due to randomisation, and deviation from intended intervention (assignment and adhering))*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(Gripstrength)-MeanSD-Robotic Rehabilitation-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Due to randomisation, and deviation from intended intervention (assignment and adhering))*
Overall bias and Directness	Overall Directness	Directly applicable

Jiang, 2021

Bibliographic Reference	Jiang, S.; You, H.; Zhao, W.; Zhang, M.; Effects of short-term upper limb robot-assisted therapy on the rehabilitation of sub-acute stroke patients; Technology & Health Care; 2021; vol. 29 (no. 2); 295-303

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	No additional information.
Study type	Randomised controlled trial (RCT)
Study location	China.

Study setting	Inpatient.
Study dates	No additional information.
Sources of funding	This work was supported by a fund from the Lanzhou Science and Technology Bureau (document number: 2016-2-59).
Inclusion criteria	First ischaemic or haemorrhagic stroke as confirmed by neuroimaging (CT or MRI); age of 35 to 85 years; less than 30 days since stroke; impaired upper limb motor function and unilateral hemiplegia; sufficient cognition to understand the purpose and follow the instructions of the study (Mini Mental State Examination at least 18); ability to participate in robot therapy (Brunnstrom assessment score 3-6); no visual problems.
Exclusion criteria	Drug abuse or epilepsy; painful arthritis of the elbow, wrist or finger joints; impaired cognition; former stroke; severe neuropsychologic impairments; severe spasticity (Ashworth 3-4).
Recruitment / selection of participants	People at the inpatient rehabilitation ward of the hospital.
Intervention(s)	Robot-assisted arm therapy N=23 In addition the robot therapy group received robot therapy (Armeo Spring) for 30 minutes twice a day, for 2 weeks. The difficulty was adjusted to the needs of each person. Concomitant therapy: All received conventional rehabilitation therapy for 30 minutes twice a day, for 2 weeks.
Subgroup 1: Severity	Moderate (or NIHSS 5-14)
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour

Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information.
Comparator	Usual care N=22 Conventional rehabilitation for 30 minutes twice a day, for 2 weeks. This included neurodevelopmental techniques, functional tasks and muscle strengthening. Concomitant therapy: All received conventional rehabilitation therapy for 30 minutes twice a day, for 2 weeks.
Number of participants	45
Duration of follow-up	2 weeks (post-intervention) and 1 month (this group will be included as ≥6 months but will be downgraded for indirectness as the time is less than 6 months).
Indirectness	Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.
Additional comments	No additional information.

1

Study arms

Robot-assisted arm therapy (N = 23)
In addition the robot therapy group received robot therapy (Armeo Spring) for 30 minutes twice a day, for 2 weeks. The difficulty was adjusted to the needs of each person. Concomitant therapy: All received conventional rehabilitation therapy for 30 minutes twice a day, for 2 weeks.

Usual care (N = 22)
Conventional rehabilitation for 30 minutes twice a day, for 2 weeks. This included neurodevelopmental techniques, functional tasks and muscle strengthening. Concomitant therapy: All received conventional rehabilitation therapy for 30 minutes twice a day, for 2 weeks.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm therapy (N = 23)	Usual care (N = 22)
% Female Sample size	n = 9 ; % = 39.1	n = 7 ; % = 31.8
Mean age (SD) (years) Mean (SD)	62.43 (11.29)	66 (11.51)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR

Characteristic	Robot-assisted arm therapy (N = 23)	Usual care (N = 22)
Diabetes Sample size	n = 10 ; % = 43.5	n = 12 ; % = 54.5
Hypertension Sample size	n = 16 ; % = 69.6	n = 14 ; % = 63.6
Drinking alcohol Sample size	n = 9 ; % = 39.1	n = 11 ; % = 50
Smoking Sample size	n = 8 ; % = 34.8	n = 4 ; % = 18.2
Severity NIHSS Mean (SD)	6.13 (1.79)	6.05 (1.79)
Time after stroke (days) Mean (SD)	20.09 (5.53)	19.41 (7.04)

Outcomes

Study timepoints

- Baseline
- 2 week (Post-intervention)
- 1 month (≥6 months outcomes from this group will be downgraded for indirectness)

Continuous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 23	Robot-assisted arm therapy, 2 week, N = 23	Robot-assisted arm therapy, 1 month, N = 23	Usual care, Baseline, N = 22	Usual care, 2 week, N = 22	Usual care, 1 month, N = 22
Activities of daily living (functional independence measure) Scale range: 18-126. Final values. Mean (SD)	87.7 (16.71)	93.39 (15.99)	95.48 (15.85)	81.91 (11.82)	84.55 (12.7)	86.45 (13.25)
Arm function (Fugl-Meyer assessment) Scale range: 0-66. Final values. Mean (SD)	39.83 (8.53)	45.61 (8.83)	48.87 (8.63)	36.36 (7.25)	39.32 (8.17)	41.91 (7.71)
Arm muscle strength (Motricity Index) Scale range: 0-100. Final values. Mean (SD)	59.52 (10.32)	65.22 (9.31)	68.87 (8.64)	55.05 (8.65)	58.95 (9.33)	61.86 (9.13)
Spasticity (modified Ashworth scale) Calculated from individual patient data. Scale range: 0-5. Final values. Mean (SD)	1.22 (0.78)	1.13 (0.9)	1.09 (1.06)	1.27 (0.96)	1.32 (1.02)	1.14 (0.87)

Activities of daily living (functional independence measure) - Polarity - Higher values are better

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Arm muscle strength (Motricity Index) - Polarity - Higher values are better
Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot-assisted arm therapy-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot-assisted arm therapy-Usual care-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted arm therapy-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted arm therapy-Usual care-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot-assisted arm therapy-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot-assisted arm therapy-Usual care-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm therapy-Usual care-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm therapy-Usual care-t1

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 16 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Kahn et al.

Bibliographic Reference	Kahn, Leonard E.; Averbuch, Michele; Rymer, W. Zev; Reinkensmeyer, David J.; Comparison of robot-assisted reaching to free reaching in promoting recovery from chronic stroke; 39-44

Study details

Secondary publication of another included study- see primary study for details	Kahn et al. Robot-assisted reaching exercise promotes arm movement recovery in chronic hemiparetic stroke: a randomized controlled pilot study. Journal of neuroengineering and rehabilitation; 2006; vol. 3 (no. 1); 1-13
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Kahn, 2006

Bibliographic Reference	Kahn, Leonard E.; Zygman, Michele L.; Rymer, W. Zev; Reinkensmeyer, David J.; Robot-assisted reaching exercise promotes arm movement recovery in chronic hemiparetic stroke: a randomized controlled pilot study; Journal of neuroengineering and rehabilitation; 2006; vol. 3 (no. 1); 1-13

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm

	muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Kahn L, Averbuch M, Rymer W, Reinkensmeyer J. Comparison of robot-assisted reaching to free reaching in promoting recovery from chronic stroke. In: Mokhtari M editor(s). *Integration of Assistive Technology in the Information Age*. Amsterdam: IOS Press, 2001:39-44.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot active-assist training (N = 10)
Robot-guided active-assist arm training in an 8 week therapy programme involving 24 sessions, each lasting 45 minutes.

Free reaching training (N = 9)
'Free reaching training' that involved unconstrained, unassisted repetitive voluntary reaching in an 8 week therapy programme involving 24 sessions, each lasting 45 minutes.

Outcomes

Study timepoints
- Baseline
- 8 week (Post-intervention)

Dichotomous outcome

Outcome	Robot active-assist training, Baseline, N = 10	Robot active-assist training, 8 week, N = 10	Free reaching training, Baseline, N = 9	Free reaching training, 8 week, N = 9
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot active-assist training-Free reaching training-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Kim, 2021

Bibliographic Reference	Kim, J. H.; Ko, M. H.; Park, J. W.; Lee, H. J.; Nam, K. Y.; Nam, Y. G.; Oh, C. H.; Park, J. H.; Kwon, B. S.; Efficacy of Electromechanically-Assisted Rehabilitation of Upper Limb Function in Post-Stroke Patients: A Randomized Controlled Study; Journal Of Rehabilitation Medicine Clinical Communications; 2021; vol. 4; 1000074

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	CRIS registration number KCT0003525.

Study type	Randomised controlled trial (RCT)
Study location	Republic of Korea.
Study setting	Outpatient follow up.
Study dates	11 September 2018 to 19 March 2020.
Sources of funding	Supported by a grant of the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (grant number: HI15C1529). Device support from Man&Tel Co. Ltd, Gumi, Republic of Korea.
Inclusion criteria	Hemiplegia due to stroke; over 19 years; impaired upper limb dysfunction due to hemiplegia; ischaemic or haemorrhagic stroke confirmed by brain imaging; fair to good cognitive function in order to be able to follow instructions; ability to sit independently in a wheelchair or chair.
Exclusion criteria	Bilateral upper limb dysfunction; impaired upper limb dysfunction due to osteoarthritis or pain; severe spasticity; inability to maintain the treatment due to any aetiology; heart or lung disease etc.
Recruitment / selection of participants	No additional information.
Intervention(s)	Robot-assisted arm therapy N=23 Electromechanically-assisted upper limb training using Camillo. The training program for this device was chosen according to the person's preference and cognitive function. Both groups performed the therapeutic intervention for 30 minutes a day, 5 days a week for 4 weeks. Concomitant therapy: all people underwent additional therapy for activities of daily living for 30 minutes daily during the study period.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)

Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information.
Comparator	Usual care N=24 Occupational therapist-assisted upper limb training using a conventional method including stretching and joint exercise for the major joints of the upper extremities, and performing tasks to improve muscle strength and upper extremity motions, tailored to the subject's ability. Concomitant therapy: all people underwent additional therapy for activities of daily living for 30 minutes daily during the study period.
Number of participants	47

Duration of follow-up	4 weeks (post-intervention).
Indirectness	No additional information.
Additional comments	No additional information.

Study arms

Robot-assisted arm therapy (N = 23)
Electromechanically-assisted upper limb training using Camillo. The training program for this device was chosen according to the person's preference and cognitive function. Both groups performed the therapeutic intervention for 30 minutes a day, 5 days a week for 4 weeks. Concomitant therapy: all people underwent additional therapy for activities of daily living for 30 minutes daily during the study period.

Usual care (N = 24)
Occupational therapist-assisted upper limb training using a conventional method including stretching and joint exercise for the major joints of the upper extremities, and performing tasks to improve muscle strength and upper extremity motions, tailored to the subject's ability. Concomitant therapy: all people underwent additional therapy for activities of daily living for 30 minutes daily during the study period.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm therapy (N = 23)	Usual care (N = 24)
% Female Sample size	n = 7 ; % = 43.8	n = 9 ; % = 56.3

Characteristic	Robot-assisted arm therapy (N = 23)	Usual care (N = 24)
Mean age (SD) (years) Mean (SD)	57.17 (15.12)	62.08 (12.42)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Sample size	n = NR ; % = NR	n = NR ; % = NR
Time after stroke (days) Mean (SD)	342 (635.07)	813.67 (1225.81)

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention)

Continuous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 23	Robot-assisted arm therapy, 4 week, N = 23	Usual care, Baseline, N = 24	Usual care, 4 week, N = 24
Arm function (Fugl Meyer Assessment Upper Extremity Total score) Scale range: 0-66. Change scores. Mean (SD)	34.7 (24.27)	2.52 (5.48)	24.83 (21.71)	1.17 (4.18)
Arm muscle strength (Motricity Index) Scale range: 0-100. Change scores. Mean (SD)	55.78 (28.15)	5.74 (9.49)	38.38 (31.43)	0.54 (1.89)
Person/participant generic health-related quality of life (EQ-5D-5L) Scale range: -0.11-1. Change scores. Mean (SD)	0.53 (0.2)	0.01 (0.06)	0.28 (0.23)	0 (0.03)
Spasticity (modified Ashworth scale) Combination of values for shoulder, elbow and wrist. Scale range: 0-5. Change scores. Robot arm therapy - shoulder = -0.13 (0.38), elbow = -0.15 (0.38), wrist = -0.11 (0.34). Control: shoulder = 0.00 (0.29), elbow = 0.00 (0.29), wrist = -0.04 (0.20). Mean (SD)	0.72 (0.71)	-0.13 (0.37)	0.78 (0.8)	-0.013 (0.26)

Arm function (Fugl Meyer Assessment Upper Extremity Total score) - Polarity - Higher values are better

Arm muscle strength (Motricity Index) - Polarity - Higher values are better

Person/participant generic health-related quality of life (EQ-5D-5L) - Polarity - Higher values are better

Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Dichotomous outcomes

Outcome	Robot-assisted arm therapy, Baseline, N = 23	Robot-assisted arm therapy, 4 week, N = 23	Usual care, Baseline, N = 24	Usual care, 4 week, N = 24
Withdrawal for any reason 10 withdrew from the control group, 5 from the experimental group due to simple withdrawal or incomplete evaluation No of events	n = NA ; % = NA	n = 5 ; % = 22	n = NA ; % = NA	n = 10 ; % = 42
Adverse events - Other reported adverse events No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - Other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerAssessmentUpperExtremityTotalscore)-MeanSD-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Person/participantgenerichealth-relatedqualityoflife(EQ-5D-5L)-MeanSD-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-Otherreportedadverseevents-NoOfEvents-Robot-assisted arm therapy-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Kim, 2019

Bibliographic Reference	Kim, M. S.; Kim, S. H.; Noh, S. E.; Bang, H. J.; Lee, K. M.; Robotic-Assisted Shoulder Rehabilitation Therapy Effectively Improved Poststroke Hemiplegic Shoulder Pain: A Randomized Controlled Trial; Archives of Physical Medicine & Rehabilitation; 2019; vol. 100 (no. 6); 1015-1022

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	Clinical Trial Registration number: KCT0002696.

Study type	Randomised controlled trial (RCT)
Study location	Republic of Korea
Study setting	Outpatient follow up
Study dates	12 months starting in March 2016.
Sources of funding	Support by Wonkwang Institute of Clinical Medicine (2016-0669), Republic of Korea
Inclusion criteria	Subacute stroke patients who reported hemiplegic shoulder pain with a minimum visual analog scale of 3 points (0-10 scale).
Exclusion criteria	Significant cognitive impairment (Korean version of the Mini-Mental State Examination <15) or language deficits; preexisting shoulder pain prior to stroke; definite shoulder abnormalities in the affected limb, on radiographs; suspected complex regional pain syndrome, central pain or myofascial pain syndrome.
Recruitment / selection of participants	People were recruited consecutively from a single tertiary university hospital.
Intervention(s)	Robot-assisted arm training N=19 Robot-assisted shoulder rehabilitation therapy for 30 minutes per day, 5 times per week for a total of 20 sessions for 4 weeks. This involved achieving the maximal pain-tolerable range of motion of the shoulder joint, using the robot arm to increase that angle for approximately 10 seconds and then returning to the original position and then repeating this cycle every 5 minutes. Concomitant therapy: All people received usual care.
Subgroup 1: Severity	Moderate (or NIHSS 5-14)
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)

Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	No additional information.
Comparator	Usual care N=19 Conventional rehabilitation only. Using patient-reported outcome measures exercises and reducing neurologic injury based on the Bobath approach and performed twice a day in both groups. Additional physical agent modalities, such as hot pack application, ultasound, and transcutaneous electrical nerve stimulation and analgesics were equally administered in both groups. Other occupational, language and cognitive therapies commonly performed in stroke rehabilitation settings were carried out in both groups during the study period. Concomitant therapy: All people received usual care.
Number of participants	38

Duration of follow-up	4 weeks (post-intervention), 8 weeks (4 weeks after cessation of intervention, will be included in the ≥6 months time point but outcomes will be downgraded for indirectness as the time point is <6 months).
Indirectness	Outcome indirectness - Outcomes at 8 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.
Additional comments	Method of analysis unclear. Appears to be completers only.

Study arms

Robot-assisted arm training (N = 19)

Robot-assisted shoulder rehabilitation therapy for 30 minutes per day, 5 times per week for a total of 20 sessions for 4 weeks. This involved achieving the maximal pain-tolerable range of motion of the shoulder joint, using the robot arm to increase that angle for approximately 10 seconds and then returning to the original position and then repeating this cycle every 5 minutes. Concomitant therapy: All people received usual care.

Usual care (N = 19)

Conventional rehabilitation only. Using patient-reported outcome measures exercises and reducing neurologic injury based on the Bobath approach and performed twice a day in both groups. Additional physical agent modalities, such as hot pack application, ultasound, and transcutaneous electrical nerve stimulation and analgesics were equally administered in both groups. Other occupational, language and cognitive therapies commonly performed in stroke rehabilitation settings were carried out in both groups during the study period. Concomitant therapy: All people received usual care.

1 **Characteristics**

2 ***Arm-level characteristics***

Characteristic	Robot-assisted arm training (N = 19)	Usual care (N = 19)
% Female Sample size	n = 7 ; % = 39	n = 7 ; % = 39
Mean age (SD) (years) Mean (SD)	65.9 (9.4)	64.7 (8.3)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity NIHSS Mean (SD)	8.8 (2.4)	9.6 (2.6)
Time after stroke (Months) Mean (SD)	3.2 (0.9)	3.3 (0.9)

3

4 **Outcomes**

5 ***Study timepoints***

6 • Baseline
7 • 4 week (Post-intervention)

- 8 week (≥6 months - will be downgraded for indirectness due to being less than 6 months)

Continuous outcome

Outcome	Robot-assisted arm training, Baseline, N = 19	Robot-assisted arm training, 4 week, N = 19	Robot-assisted arm training, 8 week, N = 19	Usual care, Baseline, N = 19	Usual care, 4 week, N = 19	Usual care, 8 week, N = 19
Arm function (Korean-Shoulder Disability Questionnaire) Scale range: 0-100. Final values. Mean (SD)	96 (4)	68 (6)	65 (6)	96 (3)	83 (8)	82 (10)

Arm function (Korean-Shoulder Disability Questionnaire) - Polarity - Lower values are better

Dichotomous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 19	Robot-assisted arm training, 4 week, N = 19	Robot-assisted arm training, 8 week, N = 19	Usual care, Baseline, N = 19	Usual care, 4 week, N = 19	Usual care, 8 week, N = 19
Withdrawal for any reason Intervention: 1 due to stroke recurrence. Control: 1 due to gastric cancer. No of events	n = NA ; % = NA	n = 1 ; % = 5	n = 1 ; % = 5	n = NA ; % = NA	n = 1 ; % = 5	n = 1 ; % = 5
Adverse events - Other reported adverse events Study states no adverse events.	n = NA ; % = NA	n = 0 ; % = 5	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0

Outcome	Robot-assisted arm training, Baseline, N = 19	Robot-assisted arm training, 4 week, N = 19	Robot-assisted arm training, 8 week, N = 19	Usual care, Baseline, N = 19	Usual care, 4 week, N = 19	Usual care, 8 week, N = 19
No of events						

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - Other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Korean-ShoulderDisabilityQuestionnaire)-MeanSD-Robot-assisted arm training-Usual care-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Korean-ShoulderDisabilityQuestionnaire)-MeanSD-Robot-assisted arm training-Usual care-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 8 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

1 ***Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Usual care-t4***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

2

3 ***Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Usual care-t8***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 8 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

4

5 ***Dichotomousoutcomes-Adverseevents-otheradverseevents-NoOfEvents-Robot-assisted arm training-Usual care-t4***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

6

Dichotomousoutcomes-Adverseevents-otheradverseevents-NoOfEvents-Robot-assisted arm training-Usual care-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - Outcomes at 8 weeks will be downgraded for indirectness as they were at a time point less than 6 months but after the post-intervention follow up.)*

Kutner, 2010

Bibliographic Reference	Kutner, Nancy G.; Zhang, Rebecca; Butler, Andrew J.; Wolf, Steven L.; Alberts, Jay L.; Quality-of-life change associated with robotic-assisted therapy to improve hand motor function in patients with subacute stroke: a randomized clinical trial; Physical therapy; 2010; vol. 90 (no. 4); 493-504

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)

Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Mixed 3-9 months
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	Not stated/unclear
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robotic assisted training (N = 10)
30 hours of repetitive task training plus 30 hours of robotic assisted training over 3 weeks.

Repetitive task training (N = 11)
60 hours of repetitive task training over 3 weeks.

Outcomes

Study timepoints

- Baseline
- 3 week (Post-intervention)
- 2 month (Post-intervention)

Continuous outcomes

Outcome	Robotic assisted training, Baseline, N = 10	Robotic assisted training, 3 week, N = 10	Robotic assisted training, 2 month, N = 10	Repetitive task training, Baseline, N = 7	Repetitive task training, 3 week, N = 7	Repetitive task training, 2 month, N = 7
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-ADL domain) Scale: unclear. Change scores. Values reported in the Cochrane review used. Mean (95% CI)	NR (NR to NR)	6.89 (0.18 to 13.61)	1.88 (-6.42 to 10.17)	NR (NR to NR)	8.49 (0.39 to 16.6)	7.53 (-2.35 to 17.4)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-hand function domain) Scale: unclear. Change scores. Values reported in the Cochrane review used.	NR (NR to NR)	26.47 (14.69 to 38.26)	21.37 (7.31 to 35.44)	NR (NR to NR)	14.85 (0.64 to 29.06)	17.58 (0.84 to 34.22)

Outcome	Robotic assisted training, Baseline, N = 10	Robotic assisted training, 3 week, N = 10	Robotic assisted training, 2 month, N = 10	Repetitive task training, Baseline, N = 7	Repetitive task training, 3 week, N = 7	Repetitive task training, 2 month, N = 7
Mean (95% CI)						

Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-ADL domain) - Polarity - Higher values are better
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-hand function domain) - Polarity - Higher values are better
ADL outcome: 3 week post-intervention results noted in Cochrane review were: 6.9 (10) for the intervention group and 8.5 (11.3) for the control group. [mean plus SD converted from mean plus 95% CI reported in study]. hand function outcome: 3 week post-intervention results noted in Cochrane review were: 26.5 (17.5) for the intervention group and 14.9 (19.9) for the control group. [mean plus SD converted from mean plus 95% CI reported in study].

Dichotomous outcome

Outcome	Robotic assisted training, Baseline, N = 11	Robotic assisted training, 3 week, N = 11	Robotic assisted training, 2 month, N = 11	Repetitive task training, Baseline, N = 10	Repetitive task training, 3 week, N = 10	Repetitive task training, 2 month, N = 10
Withdrawals for any reason 3 participants in the robot group did not receive the intervention due to transport difficulties. No of events	n = NA ; % = NA	n = 3 ; % = 27	n = NA ; % = NA	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA
Adverse events Narrative statement: no adverse events were reported. No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-ADLdomain)-MeanNineFivePercentCI-Robotic assisted training-Repetitive task training-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-ADLdomain)-MeanNineFivePercentCI-Robotic assisted training-Repetitive task training-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-handfunctiondomain)-MeanNineFivePercentCI-Robotic assisted training-Repetitive task training-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-handfunctiondomain)-MeanNineFivePercentCI-Robotic assisted training-Repetitive task training-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcome-Withdrawalsforanyreason-NoOfEvents-Robotic assisted training-Repetitive task training-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalsforanyreason-NoOfEvents-Robotic assisted training-Repetitive task training-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Lee, 2016

Bibliographic Reference	Lee, Kyeong Woo; Kim, Sang Beom; Lee, Jong Hwa; Lee, Sook Joung; Yoo, Seung Wan; Effect of upper extremity robot-assisted exercise on spasticity in stroke patients; Annals of rehabilitation medicine; 2016; vol. 40 (no. 6); 961

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised

Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot-assisted therapy (N = 29)
With the robot Neuro-X over 20 sessions (30 minutes per session, 2 sessions per day, 5 days a week for 2 weeks).

Conventional therapy (N = 29)
Conventional upper extremity rehabilitation exercise twice daily.

Outcomes

Study timepoints
- Baseline
- 2 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-assisted therapy, Baseline, N = 29	Robot-assisted therapy, 2 week, N = 22	Conventional therapy, Baseline, N = 29	Conventional therapy, 2 week, N = 22
Withdrawal for any reason Robot group: 6 discharged early, 1 declined medical	n = NA ; % = NA	n = 7 ; % = 24	n = NA ; % = NA	n = 7 ; % = 24

Outcome	Robot-assisted therapy, Baseline, N = 29	Robot-assisted therapy, 2 week, N = 22	Conventional therapy, Baseline, N = 29	Conventional therapy, 2 week, N = 22
condition. Conventional group: 5 discharged early, 2 declined medical condition No of events				

Continuous outcomes

Outcome	Robot-assisted therapy, Baseline, N = 29	Robot-assisted therapy, 2 week, N = 22	Conventional therapy, Baseline, N = 29	Conventional therapy, 2 week, N = 22
Activities of daily living (Korean modified Barthel Index) Change scores reported at 2 weeks (baseline is total score). Values as reported in Cochrane review. Score 0-100 Mean (SD)	43.95 (19.2)	10 (7.1)	45.27 (13.87)	9.6 (6.5)
Arm function (Manual function Test) Change scores reported at 2 weeks (baseline is total score). Values as reported in Cochrane review. Score 0-32. Mean (SD)	6.77 (4.81)	1.6 (1.5)	6.32 (4.8)	1.2 (1.8)
Arm muscle strength (Manual Muscle Test) Change scores. Values as reported in Cochrane review. Score 0-5 Mean (SD)	NR (NR)	0.3 (0.5)	NR (NR)	0.2 (0.4)

Outcome	Robot-assisted therapy, Baseline, N = 29	Robot-assisted therapy, 2 week, N = 22	Conventional therapy, Baseline, N = 29	Conventional therapy, 2 week, N = 22
(Elbow flexor) Spasticity (modified Ashworth scale) Change scores reported at 2 weeks (baseline is total score). Score 0-5 Mean (SD)	1.91 (0.92)	-0.41 (0.5)	2.09 (0.61)	-0.23 (0.43)
(Shoulder adductor) Spasticity (modified Ashworth scale) Change scores reported at 2 weeks (baseline is total score). Score 0-5. Mean (SD)	1.77 (0.81)	-0.36 (0.49)	1.82 (0.73)	-0.23 (0.43)

Activities of daily living (Korean modified Barthel Index) - Polarity - Higher values are better
Arm function (Manual function Test) - Polarity - Higher values are better
Arm muscle strength (Manual Muscle Test) - Polarity - Higher values are better
(Elbow flexor) Spasticity (modified Ashworth scale) - Polarity - Lower values are better
(Shoulder adductor) Spasticity (modified Ashworth scale) - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(KoreanmodifiedBarthelIndex)-MeanSD-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(ManualfunctionTest)-MeanSD-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(ManualMuscleTest)-MeanSD-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-(Elbowflexor)Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-(Shoulderadductor)Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted therapy-Conventional therapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Lee, 2018

Bibliographic Reference	Lee, M. J.; Lee, J. H.; Lee, S. M.; Effects of robot-assisted therapy on upper extremity function and activities of daily living in hemiplegic patients: A single-blinded, randomized, controlled trial; Technology & Health Care; 2018; vol. 26 (no. 4); 659-666

Study details

Secondary publication of another included study- see primary study for details	NR

Other publications associated with this study included in review	NR
Trial name / registration number	NR
Study location	Korea
Study setting	rehabilitation hospital
Study dates	NR
Sources of funding	NR
Inclusion criteria	Patients were diagnosed with stroke induced hemiplegia occurring at least 6 months before study enrolment; patients were capable of communicating on their own with a score of > 21 points on the Korean version of the mini-mental state examination (MMSE-K); patients had a muscle tone of grade 2 or below on the Modified Ashworth scale in the hemiplegic upper extremity; patients had a minimally functional upper limb (FMA score >35).
Exclusion criteria	Patients with visual perception and cognitive deficits; patients with joint contracture or limited range of joint motion; patients who were unable to perform the exercise programme due to neurological or psychiatric problems.
Recruitment / selection of participants	Sixteen subjects were recruited to each group from rehabilitation centres belonging to the corkers compensation and welfare service.
Intervention(s)	In the experimental group he same treatment was applied as the control group for the same period of 30 mins of the REJOYCE robot treatment which led the use of the upper limb. The robotic device comprised of a notebook computer, a screen and a controller . the controller had 9 types of manipulation functions necessary t perform ADL such as: gross motor functions involving doorknobs, handles, jars, pouring a cup with water and fine motor functions involving keys and coins. Depending on the programmes settings the user could focus on training certain movements and strength. the degree of difficulty could be changed depending on the persons condition. 3 types of movement programme were applied for 10 mins each for a total of 30 mins.

	Concomitant therapy - Both groups received general occupational therapy consisting of 5, 30 min sessions per week for 8 weeks. The experimental group received a additional 30 min of robot assisted therapy, while the control group received an additional 30 min of general occupational therapy during each sessions over the same time period.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	Both groups received general occupational therapy consisting of 5, 30 min sessions per week for 8 weeks. The experimental group received a additional 30 min of robot assisted therapy, while the control group received an additional 30

	min of general occupational therapy during each sessions over the same time period. General occupational therapy comprised of stretching exercises, neurodevelopmental therapy, resistance exercise and fine motor training.
Number of participants	30
Duration of follow-up	8 weeks end of intervention
Indirectness	NR
Additional comments	NR

Study arms

Robot therapy (N = 15)

conventional therapy (N = 15)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 30)**
Ethnicity Nominal	NR
Comorbidities Nominal	NR

Characteristic	Study (N = 30)
Severity Nominal	NR

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2 ***Arm-level characteristics***

Characteristic	Robot therapy (N = 15)	conventional therapy (N = 15)
% Female Nominal	46.7	26.7
Mean age (SD) Mean (SD)	52.07 (14.07)	50.27 (11.17)
Time after stroke Nominal	NR	NR
7-12 months Nominal	26.7	20
13-24 months Nominal	40	46.7
25 and above Nominal	33.3	33.3

3

Outcomes

Study timepoints

- Baseline
- 8 week

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 8 week, N = 15	conventional therapy, Baseline, N = 15	conventional therapy, 8 week, N = 15
Activities of daily living (Modified Barthel Index) 0-100, change scores Mean (SD)	75.8 (10.31)	5.8 (5.73)	67.13 (15.14)	3.33 (4.95)
Arm function (Fugl Meyer UE) 0-66, change score Mean (SD)	51.87 (10.57)	8.2 (8.6)	50 (7.84)	2.33 (3.31)
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0

Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better
Arm function (Fugl Meyer UE) - Polarity - Higher values are better
Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-Robot therapy-conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-Robot therapy-conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Lemmens, 2014

Bibliographic Reference	Lemmens, Ryanne J. M.; Timmermans, Annick A. A.; Janssen-Potten, Yvonne J. M.; Pulles, Sanne Antd; Geers, Richard P. J.; Bakx, Wilbert G. M.; Smeets, Rob J. E. M.; Seelen, Henk A. M.; Accelerometry measuring the outcome of robot-supported upper limb training in chronic stroke: a randomized controlled trial; PloS one; 2014; vol. 9 (no. 5); e96414

Study details

Secondary publication of another included study- see primary study for details	Timmermans et al. Effects of task-oriented robot training on arm function, activity, and quality of life in chronic stroke patients: a randomized controlled trial.mJournal of neuroengineering and rehabilitation; 2014; vol. 11 (no. 1); 1-12
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Lencioni, 2021

Bibliographic Reference	Lencioni, T.; Fornia, L.; Bowman, T.; Marzegan, A.; Caronni, A.; Turolla, A.; Jonsdottir, J.; Carpinella, I.; Ferrarin, M.; A randomized controlled trial on the effects induced by robot-assisted and usual-care rehabilitation on upper limb muscle synergies in post-stroke subjects; Scientific Reports; 2021; vol. 11 (no. 1); 5323

Study details

Secondary publication of another included study- see primary study for details	Carpinella, I. et al. Effects of robot therapy on upper body kinematics and arm function in persons post stroke: a pilot randomized controlled trial. J. Neuroeng. Rehabil. 17, 10 (2020).

Other publications associated with this study included in review	NR
Trial name / registration number	

Study arms

Robot therapy (N = 20)

Conventional therapy (N = 20)

Liao, 2012

Bibliographic Reference	Liao, Wan-wen; Wu, Ching-yi; Hsieh, Yu-wei; Lin, Keh-chung; Chang, Wan-ying; Effects of robot-assisted upper limb rehabilitation on daily function and real-world arm activity in patients with chronic stroke: a randomized controlled trial; Clinical rehabilitation; 2012; vol. 26 (no. 2); 111-120

Study details

Secondary publication of another included	Hsieh YW, Wu CY, Liao WW, Lin KC, Wu KY, Lee CY. Effects of treatment intensity in upper limb robot-assisted therapy for chronic stroke: a pilot randomized controlled trial. *Neurorehabilitation and Neural Repair* 2011;25(6):503-11.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Mixed

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Study arms

Robot-assisted therapy (N = 10)
With Bi-Manu -Track over 4 weeks, 5 days a week for 90 to 105 minutes per session. After robot training, participants received 15 minutes of training in functional activities.

Active control therapy (N = 10)
Protocol-based occupational therapy techniques. The control group received the same amount of therapy hours as the treatment group; after the active control therapy session the participants also received 15 minutes of training in functional activities.

Outcomes

Study timepoints
- Baseline
- 4 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-assisted therapy, Baseline, N = 10	Robot-assisted therapy, 4 week, N = 10	Active control therapy, Baseline, N = 10	Active control therapy, 4 week, N = 10
Withdrawal for any reason No of events	n = NR ; % = NR	n = 0 ; % = 0	n = NR ; % = NR	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot-assisted therapy, Baseline, N = 10	Robot-assisted therapy, 4 week, N = 10	Active control therapy, Baseline, N = 10	Active control therapy, 4 week, N = 10
Activities of daily living (ABILHAND) Change scores. Scale range 0-69 Mean (SD)	0.99 (0.26)	0.3 (0.2)	0.92 (0.45)	0 (0.3)
Arm function (Fugl-Meyer assessment) Change scores. Scale range 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	6.3 (5.6)	NR (NR)	1.3 (7.9)

Activities of daily living (ABILHAND) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Also reports Motor Activity Log (AOU and QOM separately), and FIM for ADL.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted therapy-Active control therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(ABILHAND)-MeanSD-Robot-assisted therapy-Active control therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Active control therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Lin, 2022

Bibliographic Reference	Lin, Y; Li, QY; Qu, Q; Ding, L; Chen, Z; Huang, F; Hu, S; Deng, W; Guo, F; Wang, C; et, al.; Comparative Effectiveness of Robot-Assisted Training Versus Enhanced Upper Extremity Therapy on Upper and Lower Extremity for Stroke Survivors: a Multicentre Randomized Controlled Trial; Journal of rehabilitation medicine; 2022; jrm00314

Study details

Secondary publication of another included study- see primary study for details	No additional information.

Other publications associated with this study included in review	No additional information.
Trial name / registration number	ChiCTR2000038676
Study type	Randomised controlled trial (RCT)
Study location	China
Study setting	Outpatient follow up.
Study dates	May 2019 to July 2020.
Sources of funding	Supported by the National Key and Research Development Program of Ministry of Science and Technology of the People's Republic of China (grant numbers 2018YFC2002300 and 2018YFC2002301), the National Natural Science Foundation of China Major Research Programs (grant numbers 91948302 and 82021002) and Shanghai Municipal Health and Family Planning Commission (grant number 20194Y0509).
Inclusion criteria	Unilateral paresis with first ischaemic or haemorrhagic stroke confirmed by computed tomography or magnetic resonance imaging that occurred between 1 week and 2 years before enrollment; the ability to perform no or some active movements in the shoulder and/or elbow joints in the sitting position, allowing for trunk compensation if needed; the ability to understand and follow simple instructions.
Exclusion criteria	Bilateral impairment; multiple strokes; inability to sign informed consent; medical conditions that could interfere with training (severe auditory or visual impairments, orthopaedic contracture and severe cardiovascular disease).
Recruitment / selection of participants	No additional information.
Intervention(s)	Robot-assisted arm training N=86 Robot-assisted arm training using the FLEXO-Arm1 robot for 30 minutes, 5 days a week for 3 weeks. Training was provided by a physiotherapist. The robot exercise consisted of 2 types of movement patterns: teaching training and task-oriented training. This included 5 degrees of freedom: shoulder flexion-extension and adduction-abduction, horizontal and vertical elbow flexion-extension, and wrist flexion-extension. The teaching training included passive movements and was used for

	the first 10 minutes while the task-oriented training included active-assisted movements and was used for the second 20 minutes. Concomitant therapy: All people received conventional rehabilitation, 5 days a week for 3 weeks, divided into two 30 minute sessions of physiotherapy and occupational therapy.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.

Comparator	Any other intervention (task oriented training) N=86 Enhanced occupational therapy that was time matched to the robot arm training. Concomitant therapy: All people received conventional rehabilitation, 5 days a week for 3 weeks, divided into two 30 minute sessions of physiotherapy and occupational therapy.
Number of participants	172
Duration of follow-up	3 weeks (end of intervention)
Indirectness	No additional information.
Additional comments	Methods of analyses are intention to treat and per protocol analyses.

Study arms

Robot-assisted arm training (N = 86)
Robot-assisted arm training using the FLEXO-Arm1 robot for 30 minutes, 5 days a week for 3 weeks. Training was provided by a physiotherapist. The robot exercise consisted of 2 types of movement patterns: teaching training and task-oriented training. This included 5 degrees of freedom: shoulder flexion-extension and adduction-abduction, horizontal and vertical elbow flexion-extension, and wrist flexion-extension. The teaching training included passive movements and was used for the first 10 minutes while the task-oriented training included active-assisted movements and was used for the second 20 minutes. Concomitant therapy: All people received conventional rehabilitation, 5 days a week for 3 weeks, divided into two 30 minute sessions of physiotherapy and occupational therapy.

Any other intervention (task oriented training) (N = 86)

Enhanced occupational therapy that was time matched to the robot arm training. Concomitant therapy: All people received conventional rehabilitation, 5 days a week for 3 weeks, divided into two 30 minute sessions of physiotherapy and occupational therapy.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 86)	Any other intervention (task oriented training) (N = 86)
% Female Sample size	n = 22 ; % = 26.8	n = 22 ; % = 25.6
Mean age (SD) (years) Mean (SD)	59.37 (10.96)	58.72 (12.89)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Mean (SD)	NR (NR)	NR (NR)
Time after stroke (days) Mean (SD)	142.3 (162.84)	158.23 (178.2)

Outcomes

Study timepoints

- Baseline
- 3 week (End of intervention)

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 82	Robot-assisted arm training, 3 week, N = 72	Any other intervention (task oriented training), Baseline, N = 86	Any other intervention (task oriented training), 3 week, N = 72
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Change scores. Per protocol. Mean (SD)	31.23 (18.95)	7.01 (6.94)	25.69 (14.46)	5.63 (5.24)
Activities of daily living (Modified Barthel Index) Scale range: 0-100. Change scores. Mean (SD)	66.04 (23.47)	10.81 (9.98)	58.97 (24.19)	9.99 (10.72)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better

Continuous outcomes (mean difference)

Outcome	Robot-assisted arm training vs Any other intervention (task oriented training), Baseline, N2 = 72, N1 = 72	Robot-assisted arm training vs Any other intervention (task oriented training), 3 week, N2 = 72, N1 = 72
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Change scores. Adjusted mean difference using the per-protocol set. Mean (95% CI)	NA (NA to NA)	1.33 (-0.71 to 3.37)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 86	Robot-assisted arm training, 3 week, N = 86	Any other intervention (task oriented training), Baseline, N = 86	Any other intervention (task oriented training), 3 week, N = 86
Withdrawal for any reason Intervention: 4 did not receive the intervention due to covid-19, 1 lost to follow up, 1 adverse event, 3 withdrew consent, 1 discharge for covid 19, 4 discharged for personal reasons. Control: 1 selective operation, 1 adverse event, 2 withdrew consent, 2 discharged for covid-19, 9 discharged for personal reason No of events	n = NA ; % = NA	n = 14 ; % = 16	n = NA ; % = NA	n = 14 ; % = 16
Adverse events - other reported adverse events Each arm had 1 withdrawal due to adverse events - downgrade due to indirectness	n = NA ; % = NA	n = 1 ; % = 2	n = NA ; % = NA	n = 1 ; % = 2

Outcome	Robot-assisted arm training, Baseline, N = 86	Robot-assisted arm training, 3 week, N = 86	Any other intervention (task oriented training), Baseline, N = 86	Any other intervention (task oriented training), 3 week, N = 86
No of events				

Withdrawal for any reason - Polarity - Lower values are better

Adverse events - other reported adverse events - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-Robot-assisted arm training-Any other intervention (task oriented training)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes(meandifference)-Armfunction(FuglMeyerassessment-upperextremity)-MeanNineFivePercentCI-Robot-assisted arm training-Any other intervention (task oriented training)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Any other intervention (task oriented training)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-otherreportedadverseevents-NoOfEvents-Robot-assisted arm training-Any other intervention (task oriented training)-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Partially applicable *(Outcome indirectness - withdrawal adverse events reported only (does not report any other adverse events))*

Linder, 2013

Bibliographic Reference	Linder, Susan M.; Rosenfeldt, Anson B.; Reiss, Aimee; Buchanan, Sharon; Sahu, Komal; Bay, Curtis R.; Wolf, Steven L.; Alberts, Jay L.; The home stroke rehabilitation and monitoring system trial: a randomized controlled trial; International journal of stroke; 2013; vol. 8 (no. 1); 46-53

1 **Study details**

Secondary publication of another included study- see primary study for details	Wolf et al. The HAAPI (Home Arm Assistance Progression Initiative) trial: a novel robotics delivery approach in stroke rehabilitation. Neurorehabilitation and neural repair; 2015; vol. 29 (no. 10); 958-968
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

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4 **Lo, 2010**

Bibliographic Reference	Lo, Albert C.; Guarino, Peter D.; Richards, Lorie G.; Haselkorn, Jodie K.; Wittenberg, George F.; Federman, Daniel G.; Ringer, Robert J.; Wagner, Todd H.; Krebs, Hermano I.; Volpe, Bruce T.; Robot-assisted therapy for long-term upper-limb impairment after stroke; New England Journal of Medicine; 2010; vol. 362 (no. 19); 1772-1783

5

6 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

Study arms

Intensive robot-assisted therapy (N = 49)
Maximum of 36 sessions over 12 weeks.

Non-robot therapy (N = 78)
Intensive comparison therapy which matched the robot therapy in schedule and in form of intensity of movements. (n=50) Customary care (i.e. medical management , clinic visits needed and in some cases, rehabilitation services). (n=28) These groups were collapsed into one control group in analysis.

Outcomes

Study timepoints
- Baseline
- 12 week (Post-intervention)

Dichotomous outcome

Outcome	Intensive robot-assisted therapy, Baseline, N = 49	Intensive robot-assisted therapy, 12 week, N = 49	Non-robot therapy, Baseline, N = 78	Non-robot therapy, 12 week, N = 78
Withdrawal for any reason Values as reported in Cochrane review. Robot group: 3 withdrew consent, 1 lost to follow-up, 1 hospitalised. Comparison group: 3 died, 4 withdrew consent, 2 lost to follow-up, 1 hospitalised, 1 unable to travel. No of events	n = NA ; % = NA	n = 5 ; % = 10	n = NA ; % = NA	n = 11 ; % = 14
Adverse events Related to study therapy. Included pain/ stiffness,/ soreness, fatigue, swelling/ bruising, cut/ scratch/ irritation and numbness. No of events	n = NA ; % = NA	n = 12 ; % = 24	n = NA ; % = NA	n = 9 ; % = 18

Continuous outcomes

Outcome	Intensive robot-assisted therapy, Baseline, N = 49	Intensive robot-assisted therapy, 12 week, N = 49	Non-robot therapy, Baseline, N = 78	Non-robot therapy, 12 week, N = 78
Arm function (Fugl-Meyer assessment) Change scores. Scale 0-66. Values are those reported in Cochrane review. Mean (SD)	NA (NA)	3.9 (7.4)	NA (NA)	0 (6.4)
Spasticity (Ashworth MAS) Change scores. Scale 0-5. Values calculated from mean plus SE reported. Mean (SD)	NA (NA)	-0.07 (0.09)	NA (NA)	0.06 (0.5)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale) Change score. Scale range 0-100. Values are those reported in the Cochrane review. Mean (SD)	NA (NA)	6.3 (11.8)	NA (NA)	1.4 (12.1)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Spasticity (Ashworth MAS) - Polarity - Lower values are better

Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale) - Polarity - Higher values are better

For spasticity outcome, values were calculated from means and SE reported. Values reported in paper: usual care: -0.04 (0.11), intensive comparison therapy: 0.12 (0.09)

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Intensive robot-assisted therapy-Non-robot therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Adverseevents-NoOfEvents-Intensive robot-assisted therapy-Non-robot therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Intensive robot-assisted therapy-Non-robot therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-Intensive robot-assisted therapy-Non-robot therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale)-MeanSD-Intensive robot-assisted therapy-Non-robot therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Lum, 2002

Bibliographic Reference	Lum, Peter S.; Burgar, Charles G.; Shor, Peggy C.; Majmundar, Matra; Van der Loos, Machiel; Robot-assisted movement training compared with conventional therapy techniques for the rehabilitation of upper-limb motor function after stroke; Archives of physical medicine and rehabilitation; 2002; vol. 83 (no. 7); 952-959

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm

this study included in review	muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Burgar C, Lum P, Shor P, Van der Loos H. Development of robots for rehabilitation therapy: the Palo Alto VA/Stanford experience. *Journal of Rehabilitation Research and Development* 2000;37(6):663-73. Burgar CG, Lum PS, Shor M, Loos HFM. Rehabilitation of upper limb dysfunction in chronic hemiplegia: robot-assisted movement versus conventional therapy. *Archives of Physical Medicine and Rehabilitation* 1999;80:1121.
Study type	Randomised controlled trial (RCT)
Sources of funding	
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised

Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot therapy (N = 15)
Received bimanual and passive robot therapy by the MIME robot as per the control group.

Physiotherapy (N = 15)
Received 55 minutes of physiotherapy for the arm and 5 minutes of robot training for each of the 24 sessions over a 2 month period.

Outcomes

Study timepoints
- Baseline
- 2 month (Post-intervention)
- 6 month (Post-intervention.)

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 2 month, N = 15	Robot therapy, 6 month, N = 15	Physiotherapy, Baseline, N = 15	Physiotherapy, 2 month, N = 15	Physiotherapy, 6 month, N = 15
Withdrawal for any reason 2 dropped out because of medical	n = NA ; % = NA	n = 2 ; % = 13	n = NR ; % = NR	n = NA ; % = NA	n = 1 ; % = 8	n = NR ; % = NR

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 2 month, N = 15	Robot therapy, 6 month, N = 15	Physiotherapy, Baseline, N = 15	Physiotherapy, 2 month, N = 15	Physiotherapy, 6 month, N = 15
complications unrelated to the study, and 1 participant's data were not included in the analysis due late confirmation of ineligibility for the trial. Groups not reported. No of events						

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 2 month, N = 13	Robot therapy, 6 month, N = 13	Physiotherapy, Baseline, N = 15	Physiotherapy, 2 month, N = 14	Physiotherapy, 6 month, N = 14
Activities of daily living (barthel index) Change scores. Scale 0-100. Mean (SE)	90.8 (2.6)	1.2 (1.2)	2.1 (1.3)	84.8 (3.3)	0 (0)	0.4 (0.4)
Arm function (Fugl-Meyer assessment)-proximal limb Change scores. Scale 0-42. Mean (SE)	NR (NR)	3.3 (0.7)	3.6 (1)	NR (NR)	1.6 (0.3)	2.8 (0.8)
Arm function (Fugl-Meyer assessment)-distal limb	NR (NR)	1.4 (0.5)	1.3 (0.4)	NR (NR)	1.5 (0.5)	2 (0.6)

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 2 month, N = 13	Robot therapy, 6 month, N = 13	Physiotherapy, Baseline, N = 15	Physiotherapy, 2 month, N = 14	Physiotherapy, 6 month, N = 14
Change scores. Scale 0-24. Mean (SE)						

Activities of daily living (barthel index) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment)- proximal limb - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment)- distal limb - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-distallimb-MeanSE-Robot therapy-Physiotherapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot therapy-Physiotherapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(barthelindex)-MeanSE-Robot therapy-Physiotherapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(barthelindex)-MeanSE-Robot therapy-Physiotherapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-proximallimb-MeanSE-Robot therapy-Physiotherapy-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-proximallimb-MeanSE-Robot therapy-Physiotherapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-distallimb-MeanSE-Robot therapy-Physiotherapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Lum, 2006

Bibliographic Reference	Lum, Peter S.; Burgar, Charles G.; Van der Loos, Machiel; Shor, Peggy C.; Majmundar, Matra; Yap, Ruth; MIME robotic device for upper-limb neurorehabilitation in subacute stroke subjects: A follow-up study; Journal of rehabilitation research & development; 2006; vol. 43 (no. 5)

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm

this study included in review	muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months) 1-5 months
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot therapy (N = 24)

Group 1: robot unilateral group performed exercises with the MIME device that progressed from the easiest exercise modes (passive) to the most challenging (active-constrained); no bilateral exercise was performed. Group 2: robot-bilateral group practised that same

12 reaching movements as in group 1, but only in bilateral mode with the MIME device. Group 3: Robot-combined group spent approximately half the treatment time in unilateral mode (as in group p1) and the other half in the bilateral mode with the MIME device. The 3 groups were combined for analysis.

Conventional therapy (N = 6)
Received an equivalent intensity and duration of conventional therapy targeting proximal upper limb function based on neurodevelopmental treatment.

Outcomes

Study timepoints

- Baseline
- 4 week (Post-intervention)
- 6 month (Post-intervention)

Dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 24	Robot therapy, 4 week, N = 24	Robot therapy, 6 month, N = 24	Conventional therapy, Baseline, N = 6	Conventional therapy, 4 week, N = 6	Conventional therapy, 6 month, N = 6
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 6 ; % = 25	n = NA ; % = NA	n = 0 ; % = 0	n = 1 ; % = 17

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 24	Robot therapy, 4 week, N = 24	Robot therapy, 6 month, N = 18	Conventional therapy, Baseline, N = 6	Conventional therapy, 4 week, N = 6	Conventional therapy, 6 month, N = 5
Activities of daily living (functional independence measure) Change scores. Scale 0-63. Values at 4 weeks as reported in Cochrane review. Values at 6 months calculated from SEs reported. Mean (SD)	NA (NA)	2.9 (1.2)	4 (5.9)	NA (NA)	3.2 (1.4)	5.2 (3.8)
Arm function (Fugl-Meyer assessment- overall) Change scores. Scale 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	7 (1.8)	NR (NR)	NR (NR)	6.5 (2.5)	NR (NR)
Arm function (Fugl-Meyer assessment)- proximal limb Change scores. Scale 0-42. Calculated from SEs provided Mean (SD)	NA (NA)	NA (NA)	6.1 (4.3)	NA (NA)	NA (NA)	7.6 (2.7)
Arm function (Fugl-Meyer assessment)- distal limb Change scores. Scale 0-24. Calculated from SEs provided. Mean (SD)	NA (NA)	NA (NA)	5.3 (5.1)	NA (NA)	NA (NA)	6.2 (5.6)

Outcome	Robot therapy, Baseline, N = 24	Robot therapy, 4 week, N = 24	Robot therapy, 6 month, N = 18	Conventional therapy, Baseline, N = 6	Conventional therapy, 4 week, N = 6	Conventional therapy, 6 month, N = 5
Arm strength (Motor Power) Change scores. Scale 0-70. Values for 4 week outcomes as reported in Cochrane review. Values for 6 month outcomes calculated from SEs reported. Mean (SD)	NA (NA)	7.9 (7.5)	15.8 (7.9)	NA (NA)	9.3 (3.2)	14.2 (5.1)
Spasticity (Ashworth scale)- proximal Change scores. Scale 0-15. Calculated from SEs provided. Mean (SD)	NA (NA)	-0.04 (1.9)	-5.1 (2.4)	NA (NA)	-1.3 (1.7)	0.2 (1.8)
Spasticity (Ashworth scale)- distal Change scores. Scale 0-30. Calculated from SEs provided. Mean (SD)	NA (NA)	-0.38 (0.8)	-0.8 (1.6)	NA (NA)	0.7 (1.5)	0.8 (1.6)

Activities of daily living (functional independence measure) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment- overall) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment)- proximal limb - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment)- distal limb - Polarity - Higher values are better
Arm strength (Motor Power) - Polarity - Higher values are better
Spasticity (Ashworth scale)- proximal - Polarity - Lower values are better
Spasticity (Ashworth scale)- distal - Polarity - Lower values are better
FIM outcome at 6 months: robot combined group: 2.8 (SE 2.4), robot unilateral group: 4.3 (SE 2.7), robot bilateral: 5 (SE 1.4), control group: 5.2 (SE 1.7). Proximal FM outcome at 6 months: robot combined group: 6 (SE 1.4), robot unilateral group: 7.3 (SE 2.0), robot bilateral: 4.4 (SE 1.3, control group: 7.6 (SE 1.2). Distal FM outcome at 6 months: robot combined group: 3 (SE 1), robot unilateral

group: 8.9 (SE 2.1), robot bilateral: 3 (SE 1.5), control group: 6.2 (SE 2.5). Motor Power outcome at 6 months: robot combined group: 17.2 (SE 2.1), robot unilateral group: 17.9 (SE 3.4), robot bilateral: 11.2 (SE 3.2), control group: 14.2 (SE 2.3). Proximal Ashworth outcome at 6 months: robot combined group: -0.2 (SE 0.5), robot unilateral group: 0.3 (SE 1.1), robot bilateral: -2 (SE 0.8), control group: 0.2 (SE 0.8). Distal Ashworth outcome at 6 months: robot combined group: -0.8(SE 0.6), robot unilateral group: -0.6 (SE 0.6), robot bilateral: -1.2 (SE 0.8), control group: 0.8 (SE 0.7).

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-overall)-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-overall)-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-proximallimb-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-proximallimb-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-distallimb-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-distallimb-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MotorPower)-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MotorPower)-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-proximal-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-proximal-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-distal-MeanSD-Robot therapy-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-distal-MeanSD-Robot therapy-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Ma, 2022

Bibliographic Reference	Ma, D; Li, X; Xu, Q; Yang, F; Feng, Y; Wang, W; Huang, J-J; Pei, Y-C; Pan, Y; Robot-Assisted Bimanual Training Improves Hand Function in Patients With Subacute Stroke: a Randomized Controlled Pilot Study; Frontiers in neurology; 2022; vol. 13

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	ChiCTR1900023989.
Study type	Randomised controlled trial (RCT)
Study location	Taiwan.
Study setting	Inpatients.
Study dates	No additional information.
Sources of funding	Supported by Tsinghua University Precision Medicine Research Program (No. 10001020124), the Capital Health Research and Development of Special (No. 12021B2005) and Beijing Tsinghua Changgung Hospital Youth Start Fund (No. 12019C1008).
Inclusion criteria	First-ever and unilateral ischaemic or haemorrhagic cerebrovascular accident diagnosed by computed tomography or magnetic resonance imaging (MRI); people with subacute stroke with onset between 1 and 6 months; Brunnstrom stages of recovery ranging from 2 to 4; modified Ashworth spasticity score of the distal part of the upper limb <3.
Exclusion criteria	Mini-Mental State Examination score <24; sensory aphasia or mixed aphasia; hand dysfunction combined with a fracture of the upper limb or hand; severe neuralgia of the upper limb and hand; severe neuralgia of the upper limb and hand, affecting training (visual analog scale score >5).
Recruitment / selection of participants	Inpatients with stroke who had hemiplegic hand function from the Beijing Tsinghua Changgung Hospital.

Intervention(s)	Robot-assisted arm training N=13 Robot-assisted arm training for 60 minutes, 5 days a week for 4 weeks using an exoskeleton hand, a sensor glove and a control box (Mirror Hand). The robot can provide passive support or continuous active support to one finger or all fingers. The hand can provide mirror-guided movement, detecting the movement of the unaffected hand and replicating those movements. The exercise consisted of 5 minutes of continuous passive motion, followed by three minutes of sequential individual finger continuous passive motion, then the person actively moved the unaffected hand in the sensor glove to control the affected hand on the exoskeleton hand in a mirror symmetry pattern. Initially the program was conducted without objects for 15 minutes (such as grasping, single finger movement or opposite fingers) before task oriented training. Then the person was asked to manipulate objects and achieve a specific task with a triangular task (such as grasping and moving balls, grasping and moving wooden sticks, lifting and moving conical cylinders, pinching and moving wooden blocks, and moving pegs). Each task item was performed for 10-15 minutes. After training 30 minutes of regular control training was performed. Concomitant therapy: All people received 30 minutes of regular conventional therapy, 5 days a week for 4 weeks. This consisted of passive stretching, weight-bearing training, pain management, hand manipulation skills, dexterity training and task-specific activity training.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week

Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.
Comparator	Any other intervention (usual care) N=13 60 minutes of one-on-one conventional therapy for unilateral hand functional training. Afterwards people had the same concomitant therapy. Concomitant therapy: All people received 30 minutes of regular conventional therapy, 5 days a week for 4 weeks. This consisted of passive stretching, weight-bearing training, pain management, hand manipulation skills, dexterity training and task-specific activity training.
Number of participants	26
Duration of follow-up	4 weeks (end of intervention).
Indirectness	No additional information.
Additional comments	Method of analysis unclear. Appears to be completers only.

1

Study arms

Robot-assisted arm training (N = 13)

Robot-assisted arm training for 60 minutes, 5 days a week for 4 weeks using an exoskeleton hand, a sensor glove and a control box (Mirror Hand). The robot can provide passive support or continuous active support to one finger or all fingers. The hand can provide mirror-guided movement, detecting the movement of the unaffected hand and replicating those movements. The exercise consisted of 5 minutes of continuous passive motion, followed by three minutes of sequential individual finger continuous passive motion, then the person actively moved the unaffected hand in the sensor glove to control the affected hand on the exoskeleton hand in a mirror symmetry pattern. Initially the program was conducted without objects for 15 minutes (such as grasping, single finger movement or opposite fingers) before task oriented training. Then the person was asked to manipulate objects and achieve a specific task with a triangular task (such as grasping and moving balls, grasping and moving wooden sticks, lifting and moving conical cylinders, pinching and moving wooden blocks, and moving pegs). Each task item was performed for 10-15 minutes. After training 30 minutes of regular control training was performed. Concomitant therapy: All people received 30 minutes of regular conventional therapy, 5 days a week for 4 weeks. This consisted of passive stretching, weight-bearing training, pain management, hand manipulation skills, dexterity training and task-specific activity training.

Any other intervention (usual care) (N = 13)

60 minutes of one-on-one conventional therapy for unilateral hand functional training. Afterwards people had the same concomitant therapy. Concomitant therapy: All people received 30 minutes of regular conventional therapy, 5 days a week for 4 weeks. This consisted of passive stretching, weight-bearing training, pain management, hand manipulation skills, dexterity training and task-specific activity training.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 13)	Any other intervention (usual care) (N = 13)
% Female	n = 1 ; % = 10	n = 4 ; % = 44
Sample size		

Characteristic	Robot-assisted arm training (N = 13)	Any other intervention (usual care) (N = 13)
Mean age (SD) (years) Mean (SD)	59 (10.6)	56.44 (8.79)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Mean (SD)	NR (NR)	NR (NR)
Time after stroke (Weeks) Mean (SD)	10 (5.85)	10.33 (6.24)

Only reports baseline characteristics for 10 people in the robot arm group, and 9 people in the control group.

Outcomes

Study timepoints

- Baseline
- 4 week (End of intervention)

Continuous outcome

Outcome	Robot-assisted arm training, Baseline, N = 10	Robot-assisted arm training, 4 week, N = 10	Any other intervention (usual care), Baseline, N = 9	Any other intervention (usual care), 4 week, N = 9
Arm function (Fugl-Meyer assessment- upper extremity) Scale range: 0-66. Final values. Mean (SD)	27.2 (17.03)	36.4 (16.87)	22.56 (17.17)	30.11 (20.95)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot-assisted arm training, Baseline, N = 13	Robot-assisted arm training, 4 week, N = 13	Any other intervention (usual care), Baseline, N = 13	Any other intervention (usual care), 4 week, N = 13
Withdrawal for any reason Intervention: 3 drop out. Control: 4 drop out. No of events	n = NA ; % = NA	n = 3 ; % = 23	n = NA ; % = NA	n = 4 ; % = 31

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcome-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm training-Any other intervention (usual care)-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Any other intervention (usual care)-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Marganska, 2014

Bibliographic Reference	Marganska, V. K.; Blanco, J.; Campen, K.; Three-dimensional, task-specifi c robot therapy of the arm after stroke: a multicentre, parallel-group randomised tria; Lancet Neurol; 2014; vol. 13 (no. 2); 159-166

Study details

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

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Study arms

Robotic therapy (N = 39)
Robotic therapy with ARMin, each of 3 therapy modes (mobilisation, games, and training for activities of daily living) had to be done for at least 10 minutes. Therapy was given 3 times a week for a period of 8 weeks (sum of 24 sessions). Minimum session time (excluding time for preparation, diagnostics, and documentation) was 45 minutes.

Conventional therapy (N = 38)
Receiving common neurorehabilitation treatment given to participants after stroke in outpatient facilities, namely occupational therapy or physiotherapy. Therapists were asked to give regular therapy, usually including mobilisation, games, activities of daily living, or any combination of the 3. Therapy was given 3 times a week for a period of 8 weeks (sum of 24 sessions). Minimum session time (excluding time for preparation, diagnostics, and documentation) was 45 minutes.

Outcomes

Study timepoints
- Baseline
- 8 week (Post-intervention)

Dichotomous outcome

Outcome	Robotic therapy, Baseline, N = 39	Robotic therapy, 8 week, N = 39	Conventional therapy, Baseline, N = 38	Conventional therapy, 8 week, N = 38
Withdrawal for any reason In the robot group, 1 withdrew for medical reasons. In the conventional therapy group 1 withdrew for medical reasons and 2 refused therapy.	n = NA ; % = NA	n = 1 ; % = 3	n = NA ; % = NA	n = 3 ; % = 8

Outcome	Robotic therapy, Baseline, N = 39	Robotic therapy, 8 week, N = 39	Conventional therapy, Baseline, N = 38	Conventional therapy, 8 week, N = 38
No of events				

Continuous outcomes

Outcome	Robotic therapy, Baseline, N = 39	Robotic therapy, 8 week, N = 39	Conventional therapy, Baseline, N = 38	Conventional therapy, 8 week, N = 38
Arm function (Fugl-Meyer assessment- upper extremity) Change score. Scale range 0-66. Mean (SD)	20.2 (7.1)	3.3 (1.7)	20.7 (8.2)	2.5 (1.7)
Arm muscle strength ((Nm) Mean (SD)	10 (8)	1.4 (8)	11 (7.6)	2.6 (9.5)

Arm function (Fugl-Meyer assessment- upper extremity) - Polarity - Higher values are better
Arm muscle strength (- Polarity - Higher values are better
Also reports WMFT.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robotic therapy-Conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to reporting of results)*

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(-MeanSD-Robotic therapy-Conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robotic therapy-Conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Masiero, 2012

Bibliographic Reference	Masiero, S.; Armani, M.; Ferlini, G.; Chiasera, A.; Rosati, G.; Rossi, A.; A novel robot-assisted upper-limb rehabilitation program in acute management of post-stroke patients: a randomized controlled trial; Neurorehabilitation and Neural Repair; 2012; vol. 26 (no. 4); 401

1 **Study details**

Secondary publication of another included study- see primary study for details	Masiero S, Armani M, Rosati G. Upper-limb robot-assisted therapy in rehabilitation of acute stroke patients: focused review and results of new randomized controlled trial. *Journal of Rehabilitation Research and Development* 2011;48(4):355-66.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Masiero S, Armani M, Ferlini G, Rosati G, Rossi A. Randomized trial of a robotic assistive device for the upper extremity during early inpatient stroke rehabilitation. *Neurorehabilitation and Neural Repair* 2014;28(4):377-86. [MEDLINE: 964; 1552-6844]

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4 **Masiero, 2014**

Bibliographic Reference	Masiero, Stefano; Armani, Mario; Ferlini, Gregorio; Rosati, Giulio; Rossi, Aldo; Randomized trial of a robotic assistive device for the upper extremity during early inpatient stroke rehabilitation; Neurorehabilitation and neural repair; 2014; vol. 28 (no. 4); 377-386

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6 **Study details**

Secondary publication of another included	Masiero S, Armani M, Rosati G. Upper-limb robot-assisted therapy in rehabilitation of acute stroke patients: focused review and results of new randomized controlled trial. *Journal of Rehabilitation Research and Development* 2011;48(4):355-66.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Masiero S, Armani M, Ferlini G, Chiasera A, Rosati G, Rossi A, et al. A novel robot-assisted upper-limb rehabilitation program in acute management of post-stroke patients: a randomized controlled trial. *Neurorehabilitation and Neural Repair* 2012;26(4):401. [MEDLINE: 177]

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3 **Masiero, 2011**

Bibliographic Reference	Masiero, Stefano; Armani, Mario; Rosati, Giulio; Upper-limb robot-assisted therapy in rehabilitation of acute stroke patients: focused review and results of new randomized controlled trial; J Rehabil Res Dev; 2011; vol. 48 (no. 4); 355-366

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5 **Study details**

Secondary publication of another included	No additional information.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Masiero S, Armani M, Ferlini G, Rosati G, Rossi A. Randomized trial of a robotic assistive device for the upper extremity during early inpatient stroke rehabilitation. *Neurorehabilitation and Neural Repair* 2014;28(4):377-86. [MEDLINE: 964; 1552-6844] Masiero S, Armani M, Ferlini G, Chiasera A, Rosati G, Rossi A, et al. A novel robot-assisted upper-limb rehabilitation program in acute management of post-stroke patients: a randomized controlled trial. *Neurorehabilitation and Neural Repair* 2012;26(4):401. [MEDLINE: 177]
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Mixed Within 20 days of stroke.
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week

Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

Study arms

Robot training (N = 11)
Received robotic training with the NeReBot, twice a day for 20 minutes, and 40 minutes conventional training, 5 days a week for at least 5 weeks.

Conventional functional rehabilitation (N = 10)
80 minutes per day (including proprioceptive exercises, functional re-education, gait training, occupational therapy, and passive and active-assisted mobilisation of the hand and wrist) but without specifically exercising the proximal paretic arm.

Outcomes

Study timepoints
- Baseline
- 5 week (Post-intervention.)
- 3 month (Post-intervention.)

1 ***Dichotomous outcome***

Outcome	Robot training, Baseline, N = 11	Robot training, 5 week, N = 11	Robot training, 3 month, N =	Conventional functional rehabilitation, Baseline, N = 10	Conventional functional rehabilitation, 5 week, N = 10	Conventional functional rehabilitation, 3 month, N = 10
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

2 ***Continuous outcomes***

Outcome	Robot training, Baseline, N = 11	Robot training, 5 week, N = 11	Robot training, 3 month, N = 11	Conventional functional rehabilitation, Baseline, N = 10	Conventional functional rehabilitation, 5 week, N = 10	Conventional functional rehabilitation, 3 month, N = 10
Activities of daily living (Frenchay Arm Test) Change scores. Scale range 0-5 Mean (SD)	NR (NR)	1.8 (1.4)	1.8 (1.4)	NR (NR)	1 (0.7)	0.25 (0.5)
Arm function (Fugl-Meyer assessment) Change scores. Scale range 0-66. Mean (SD)	NR (NR)	12.2 (8.3)	12.5 (8.9)	NR (NR)	13.9 (10.2)	14.21 (7.1)
Arm strength (MRC) Change score. Scale range 0-5. Values as reported in Cochrane review (appears to be average of MRC for each muscle group)	NR (NR)	0.8 (0.6)	NR (NR)	NR (NR)	1.5 (0.9)	NR (NR)

Outcome	Robot training, Baseline, N = 11	Robot training, 5 week, N = 11	Robot training, 3 month, N = 11	Conventional functional rehabilitation, Baseline, N = 10	Conventional functional rehabilitation, 5 week, N = 10	Conventional functional rehabilitation, 3 month, N = 10
Mean (SD)						
Spasticity (Ashworth MAS) Change scores. Scale range 0-5 Mean (SD)	NR (NR)	0.83 (0.28)	0.55 (0.8)	NR (NR)	0.5 (0.7)	0.75 (1.2)

Activities of daily living (Frenchay Arm Test) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm strength (MRC) - Polarity - Higher values are better
Spasticity (Ashworth MAS) - Polarity - Lower values are better
Also reports FM-SE, FM-WH, Box and Block test. ADL: Frenchay Arm test used in Cochrane review and reported here, motor FIM also reported.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-Robot training-Conventional functional rehabilitation-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot training-Conventional functional rehabilitation-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot training-Conventional functional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Activitiesofdailyliving(FrenchayArmTest)-MeanSD-Robot training-Conventional functional rehabilitation-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(FrenchayArmTest)-MeanSD-Robot training-Conventional functional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Armfunction(FugI-Meyerassessment)-MeanSD-Robot training-Conventional functional rehabilitation-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FugI-Meyerassessment)-MeanSD-Robot training-Conventional functional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Armstrength(MRC)-MeanSD-Robot training-Conventional functional rehabilitation-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MRC)-MeanSD-Robot training-Conventional functional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-Robot training-Conventional functional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Masiero, 2007

Bibliographic Reference	Masiero, Stefano; Celia, Andrea; Rosati, Giulio; Armani, Mario; Robotic-assisted rehabilitation of the upper limb after acute stroke; Archives of physical medicine and rehabilitation; 2007; vol. 88 (no. 2); 142-149

Study details

Secondary publication of another included study- see primary study for details	No additional information.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Acute (72 hours - 7 days) ≤1 week of stroke onset.
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks at least 5 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Passive movement

1

Study arms

Robot assisted training (N = 17)
Received additional early sensorimotor robotic training with the NeReBot, robot training twice a day, 5 days a week for at least 5 weeks.

Non-robot therapy group (N = 18)
Received similar exposure to the robot (30 minutes twice per week) except that the exercises were performed with the unimpaired arm.

Outcomes

Study timepoints
- Baseline
- 5 week (Post-intervention)
- 8 month (Post-intervention)

Dichotomous outcomes

Outcome	Robot assisted training, Baseline, N = 17	Robot assisted training, 5 week, N = 17	Robot assisted training, 8 month, N = 17	Non-robot therapy group, Baseline, N = 18	Non-robot therapy group, 5 week, N = 18	Non-robot therapy group, 8 month, N = 18
Withdrawal for any reason 3 dropped out during the intervention and 2 died (groups not reported). No of events	n = NA ; % = NA	n = 2 ; % = 12	n = NR ; % = NR	n = NA ; % = NA	n = 3 ; % = 17	n = NR ; % = NR

Continuous outcomes

Outcome	Robot assisted training, Baseline, N = 17	Robot assisted training, 5 week, N = 17	Robot assisted training, 8 month, N = 17	Non-robot therapy group, Baseline, N = 18	Non-robot therapy group, 5 week, N = 18	Non-robot therapy group, 8 month, N = 18
Activities of daily living (functional independence measure) Change scores. Scale range 18-126. Mean (SD)	NR (NR)	32.6 (7.2)	46.2 (10.4)	NR (NR)	25.5 (10.5)	31.8 (14.6)
Arm function (Fugl Meyer Assessment) Change scores. Scale range 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	15.8 (8.1)	NR (NR)	NR (NR)	10.3 (12.1)	NR (NR)
Arm muscle strength (MRC) Change scores. Scale range 0-5. Values as reported in Cochrane review. Mean (SD)	NR (NR)	1.7 (1.2)	NR (NR)	NR (NR)	1.2 (1)	NR (NR)
Spasticity (MAS) Change scores. Scale range 0-5 Mean (SD)	NR (NR)	0.13 (1.4)	0.13 (1.4)	NR (NR)	0.13 (0.9)	0.88 (1.4)

Activities of daily living (functional independence measure) - Polarity - Higher values are better

Arm function (Fugl Meyer Assessment) - Polarity - Higher values are better

Arm muscle strength (MRC) - Polarity - Higher values are better
Spasticity (MAS) - Polarity - Lower values are better
Function outcome was reported separately for shoulder/ elbow and wrist/ hand. Strength outcome was reported separately for deltoid, biceps and wrist flexors.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot assisted training-Non-robot therapy group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot assisted training-Non-robot therapy group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot assisted training-Non-robot therapy group-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-MeanSD-Robot assisted training-Non-robot therapy group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-MeanSD-Robot assisted training-Non-robot therapy group-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MRC)-MeanSD-Robot assisted training-Non-robot therapy group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MRC)-MeanSD-Robot assisted training-Non-robot therapy group-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(MAS)-MeanSD-Robot assisted training-Non-robot therapy group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(MAS)-MeanSD-Robot assisted training-Non-robot therapy group-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Mayr, 2008

Bibliographic Reference	Mayr, A.; Kofler, M.; Saltuari, L.; ARMOR: an electromechanical robot for upper limb training following stroke. A prospective randomised controlled pilot study; Handchirurgie, Mikrochirurgie, Plastische Chirurgie: Organ der Deutschsprachigen Arbeitsgemeinschaft fur Handchirurgie: Organ der Deutschsprachigen Arbeitsgemeinschaft fur Mikrochirurgie der Peripheren Nerven und Gefasse: Organ der V..; 2008; vol. 40 (no. 1); 66-73

Study details

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months) <3 months post stroke.
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	Not stated/unclear
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks

Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

Study arms

Robot-assisted therapy (N = 4)

group AB: the participants received over 2 weeks, t times per week robot-assisted therapy with the ARMOR device, then 2 weeks with no intervention, and then over 2 weeks, 5 times per week EMG-initiated functional electrical stimulation.

Functional Electrical Stimulation (N = 4)

group BA: the participants received 5 times per week over 2 weeks EMG-initiated functional electrical stimulation, then 2 weeks no intervention, and then 5 times per week over 2 weeks robot-assisted therapy.

Outcomes

Study timepoints

- Baseline
- 2 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-assisted therapy, Baseline, N = 4	Robot-assisted therapy, 2 week, N = 4	Functional Electrical Stimulation, Baseline, N = 4	Functional Electrical Stimulation, 2 week, N = 4
Withdrawal for any reason Values as reported in Cochrane review No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Continuous outcomes

Outcome	Robot-assisted therapy, Baseline, N = 4	Robot-assisted therapy, 2 week, N = 4	Functional Electrical Stimulation, Baseline, N = 4	Functional Electrical Stimulation, 2 week, N = 4
Arm function Chedoke-McMaster Stroke Assessment 15-105, change score Mean (SD)	NR (NR)	3 (2.9)	NR (NR)	1.3 (1.3)
Arm muscle strength (scale unclear) Values as reported in Cochrane review Mean (SD)	NR (NR)	3.6 (4.4)	NR (NR)	2.4 (4.2)

Arm function Chedoke-McMaster Stroke Assessment - Polarity - Higher values are better

Arm muscle strength (scale unclear) - Polarity - Higher values are better

Scales and ranges unclear as paper was not in English language. All information taken from Cochrane review.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Cross-over trial

Continuousoutcomes-Armmusclestrength(scaleunclear)-MeanSD-Robot-assisted therapy-Functional Electrical Stimulation-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Due to lack of allocation concealment and lack of assessor blinding.)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Functional Electrical Stimulation-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Due to lack of allocation concealment and lack of assessor blinding.)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(scaleunclear)-MeanSD-Robot-assisted therapy-Functional Electrical Stimulation-t2

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(Due to lack of allocation concealment and lack of assessor blinding.)*
Overall bias and Directness	Overall Directness	Directly applicable

Mazzoleni et al.

Bibliographic Reference	Mazzoleni, Stefano; Buono, L.; Dario, P.; Posteraro, Federico; Upper limb robot-assisted therapy in subacute and chronic stroke patients: preliminary results on initial exposure based on kinematic measures; 265-269

Study details

Secondary publication of another included study- see primary study for details	Sale et al. Effects of upper limb robot-assisted therapy on motor recovery in subacute stroke patients. Journal of neuroengineering and rehabilitation; 2014; vol. 11 (no. 1); 1-8
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Sale et al. Recovery of hand function with robot-assisted therapy in acute stroke patients: a randomized-controlled trial. International Journal of Rehabilitation Research 2014;37(3): 236-42 Mazzoleni et al., 2014. Effects of upper limb robot-assisted therapy on motor recovery of subacute stroke patients: a kinematic approach. IEEE 1-5.

Mazzoleni et al.

Bibliographic Reference	Mazzoleni, Stefano; Carrozza, Maria Chiara; Sale, Patrizio; Franceschini, Marco; Posteraro, Federico; Tiboni, Micol; Effects of upper limb robot-assisted therapy on motor recovery of subacute stroke patients: a kinematic approach; 1-5

Study details

Secondary publication of another included study- see primary study for details	Sale et al. Effects of upper limb robot-assisted therapy on motor recovery in subacute stroke patients. Journal of neuroengineering and rehabilitation; 2014; vol. 11 (no. 1); 1-8
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858 Mazzoleni et al. Upper limb robot-assisted therapy in subacute and chronic stroke patients: preliminary results on initial exposure based on kinematic measures. 5th IEEE RAS and EMBS International Conference on Biomedical Robotics and Biomechatronics, BioRob; 12-15 August, 2014. 2014: 265-269 Sale et al. Recovery of hand function with robot-assisted therapy in acute stroke patients: a randomized-controlled trial. International Journal of Rehabilitation Research 2014;37(3): 236-42

McCabe, 2015

Bibliographic Reference	McCabe, Jessica; Monkiewicz, Michelle; Holcomb, John; Pundik, Svetlana; Daly, Janis J.; Comparison of robotics, functional electrical stimulation, and motor learning methods for treatment of persistent upper extremity dysfunction after stroke: a randomized controlled trial; Archives of physical medicine and rehabilitation; 2015; vol. 96 (no. 6); 981-990

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Daly JJ, Rogers J, McCabe J, Monkiewicz M, Burdsall R, Pundik S. Recovery of actual functional tasks in response to motor learning, robotics, and functional electrical stimulation. *Stroke* 2010;41(4):e355-6.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)

Subgroup 3: Region of upper limb trained	Proximal limb the robot therapy focused on the shoulder/ elbow area.
Subgroup 4: Dose (hours per day)	≥1 hour 5 hours per day
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised 1:3 supervision
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear

Study arms

Robot-assisted arm training (N = 12)
Motor Learning Programme in a 1:3 group paradigm for 3.5 hours per day + robotic-assisted arm training with the InMotion2 Shoulder-Elbow Robot 1.5 hours per day for 12 weeks.

Motor Learning Programme (N = 27)
Motor Learning Programme in a 1:3 group paradigm for 3.5 hours per day + functional electrical stimulation for1.5 hours per day for 12 weeks. Motor Learning Programme in a 1:3 group paradigm for 5 hours per day for 12 weeks. The 2 groups were combined for analysis.

Outcomes

Study timepoints

- Baseline
- 12 week

Dichotomous outcome

Outcome	Robot-assisted arm training, Baseline, N = 12	Robot-assisted arm training, 12 week, N = 12	Motor Learning Programme, Baseline, N = 27	Motor Learning Programme, 12 week, N = 27
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 12	Robot-assisted arm training, 12 week, N = 12	Motor Learning Programme, Baseline, N = 27	Motor Learning Programme, 12 week, N = 27
Arm function (Fugl-Meyer) Change scores. Scale 0-66. Values as reported in the Cochrane review. Mean (SD)	NR (NR)	7.7 (3.8)	NR (NR)	9.4 (4.9)

Arm function (Fugl-Meyer) - Polarity - Higher values are better
Also reports AMAT. Distal and proximal FM scores also reported separately.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyer)-MeanSD-Robot-assisted arm training-Motor Learning Programme-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(comparison group included FES.)*

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Motor Learning Programme-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(comparison group included FES.)*

Orihuela-Espina, 2016

Bibliographic Reference	Orihuela-Espina, Felipe; Roldán, Giovana Femat; Sánchez-Villavicencio, Israel; Palafox, Lorena; Leder, Ronald; Sucar, Luis Enrique; Hernández-Franco, Jorge; Robot training for hand motor recovery in subacute stroke patients: a randomized controlled trial; Journal of Hand Therapy; 2016; vol. 29 (no. 1); 51-57

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement	Mixed

delivered by robotic device	

Study arms

Robot therapy (N = 9)
Robot therapy with the Amadeo (Inc. Typromotion) for 40 sessions 5 times a week for about 60 minutes.

Occupational therapy (N = 9)
Classic occupational therapy 40 sessions 5 times a week for about 60 minutes.

Outcomes

Study timepoints
- Baseline
- 8 week (Post-intervention)

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 9	Robot therapy, 8 week, N = 9	Occupational therapy, Baseline, N = 9	Occupational therapy, 8 week, N = 8
Arm function (total FMA) Change scores, scale 0-66 Mean (SD)	NR (NR)	5.7 (2.7)	NR (NR)	1.5 (2.3)

Outcome	Robot therapy, Baseline, N = 9	Robot therapy, 8 week, N = 9	Occupational therapy, Baseline, N = 9	Occupational therapy, 8 week, N = 8
Arm muscle strength (Motricity Index) Change scores. Scale 0-100 Mean (SD)	NR (NR)	12 (7.8)	NR (NR)	5.3 (6.6)

Arm function (total FMA) - Polarity - Higher values are better

Arm muscle strength (Motricity Index) - Polarity - Higher values are better

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 9	Robot therapy, 8 week, N = 9	Occupational therapy, Baseline, N = 9	Occupational therapy, 8 week, N = 9
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(totalFMA)-MeanSD-Robot therapy-Occupational therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to no details on randomisation and allocation concealment)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot therapy-Occupational therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to no details on randomisation and allocation concealment)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot therapy-Occupational therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to no details on randomisation and allocation concealment)*
Overall bias and Directness	Overall Directness	Directly applicable

Padua, 2020

Bibliographic Reference

Padua, L.; Imbimbo, I.; Aprile, I.; Loreti, C.; Germanotta, M.; Coraci, D.; Piccinini, G.; Pazzaglia, C.; Santilli, C.; Cruciani, A.; Carrozza, M. C.; Pecchioli, C.; Loreti, S.; Lattanzi, S.; Cortellini, L.; Papadopoulou, D.; Liberti, G.; Panzera, F.; Mitrione, P.; Ruzzi, D.; Rinaldi, G.; Insalaco, S.; De Santis, F.; Spinelli, P.; Marsan, S.; Bastoni, I.; Pellegrino, A.; Petitti, T.; Montesano, A.; Castagna, A.; Grosso, C.; Ammenti, P.; Cattaneo, D.; Azzinnaro, L.; Barbieri, D.; Cassani, S.; Corrini, C.; Meotti, M.; Parelli, R.; Spedicato, A.; Zocchi, M.; Loffi, M.; Manenti, D.; Negri, L.; Gramatica, F.; Gower, V.; Galeri, S.; Noro, F.; Medici, L.; Garattini, R.; Bariselli, F.; Luli, M.; Ricca, M.; Negrini, S.; Diverio, M.; Giannini, E.; Gabrielli, A.; Deidda, B.; Gnetti, B.; Beatini, P.; Callegari, S.; Cabano, B.; Converti, F.; Pizzi, A.; Falsini, C.; Romanelli, A.; De Luca, G.; Vannetti, F.; Simoncini, E.; Martini, M.; Peccini, E.; Cecchi, F.; Avila, L.; Gabrielli, M. A.; Barilli, M.; Bertocchi, E.; Giannarelli, G.; Lerda, E.; Vasoli, M.; Rossi, P.; Marsili, V.; Tognoli, B.; Bertolini, A.; Vastola, G.; Speranza, G.; Colella, M.; Mosca, R.; Competiello, G.; Chiusano, A.; Della Vecchia, A.; Soriano, P.; Pagliarulo, M.; Remollino, V.; Langone, E.; Santarsiero, R.; Magliulo, M.; Araneo, G.; Galantucci, L.; Lioi, N.; Marrazzo, F.; Larocca, S.; Calia, R.; Benevento, S.; Toscano, O.; Lategana, M.; Cognitive reserve as a useful variable to address robotic or conventional upper limb rehabilitation treatment after stroke: a multicentre study of the Fondazione Don Carlo Gnocchi; European Journal of Neurology; 2020; vol. 27 (no. 2); 392-398

Study details

Secondary publication of another included study- see primary study for details	Aprile, Irene MD, PhD; Germanotta, Marco PhD; Cruciani, Arianna PT; Loreti, Simona MD; Pecchioli, Cristiano BS; Cecchi, Francesca MD; Montesano, Angelo MD; Galeri, Silvia MD; Diverio, Manuela MD; Falsini, Catuscia MD; Speranza, Gabriele MD; Langone, Emanuele MD; Papadopoulou, Dionysia PT; Padua, Luca MD, PhD; Carrozza, Maria Chiara PhD; for the FDG Robotic Rehabilitation Group Upper Limb Robotic Rehabilitation After Stroke: A Multicenter, Randomized Clinical Trial, Journal of Neurologic Physical Therapy: January 2020 - Volume 44 - Issue 1 - p 3-14doi: 10.1097/NPT.0000000000000295

Park, 2021

Bibliographic Reference	Park, J. H.; The effects of robot-assisted left-hand training on hemispatial neglect in older patients with chronic stroke: A pilot and randomized controlled trial; Medicine; 2021; vol. 100 (no. 9); e24781

Study details

Secondary publication of another included study- see primary study for details	Nr
Other publications associated with this study included in review	NR

Trial name / registration number	TCTR20200222005
Study location	South Korea
Study setting	rehabilitation hospital
Study dates	NR
Sources of funding	This work was supported by the Soonchunhyang University Research Fund. This work was supported by the Korea Institute for Advancement of Technology(KIAT) grant funded by the Korea Government(MOTIE) (P0012724, The Competency Development Program for Industry Specialist) This work was supported by the Soonchunhyang University Research Fund and the Korea Institute for Advancement of Technology(KIAT) grant funded by the Korea Government(MOTIE) (P0012724, The Competency Development Program for Industry Specialist). The proofreading of this manuscript were conducted by these funding sources. In addition, these funding sources were used to rent places and meals when having several meetings.
Inclusion criteria	The inclusion criteria were: (1) over 65 years of age, (2) right hemisphere stroke confirmed by a computed tomography scan or magnetic resonance imaging, (3) first-ever ischemic or haemorrhage stroke, (4) intact global cognitive function confirmed by the Korean version of Mini-Mental State Examination score ≥ 24, (5) time since stroke onset ≥ 6 months, and (6) the presence of hemispatial neglect diagnosed by performance on the Line Bisection Test and the Korean version of the Motor-free Visual Perception Test-Third Edition (MVPT-3).
Exclusion criteria	The exclusion criteria were: (1) any additional treatment for hemispatial neglect, (2) left upper limb sensory deficit or impairment, (3) visual impairment, (4) the modified Ashworth scale score for left-hand muscle tone ≥ 2, (5) below second-grade left hand muscle strength in a manual muscle test, (6) orthopaedic conditions involving the left upper limb, and (7) apraxia.
Recruitment / selection of participants	NR
Intervention(s)	The Robot therapy group performed 20 sessions (five days a week for four weeks) of robot-assisted hand training using the Amadeo Robotic device (Trymotion GmbH, Graz, Austria) (Figure 1). The end-effector based Amadeo Robot has five degrees of freedom and provides the motion of one or all five fingers through a passive rotational joint placed between the

	fingertip and an entity moves laterally (the thumb has two passive rotational joints). All five translational degrees of freedom are independent and almost entirely cover the fingers' workspace. The interface between the human hand and the machine is achieved via elastic bands or plasters and the wrist is restrained from movement by a Velcro strap. Each session lasted 30 minutes. The exercises were carried out according to a previous study as follow: (1) grasp and release training (digital joint flexion/extension exercise from the thumb to the fifth finger) for 15 minutes; and (2) count training (count a number sequence from one to five) for 15 minutes. The participant's hand motion was assisted by the robot and adjusted to the individual's level of function through the assistive therapy mode of the Amadeo robot. During the training, the participants in the EG received visual feedback of their hand movements via video animation presented on a monitor.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Passive movement
Population subgroups	NR

Comparator	The control group received the 20 sessions of the conventional treatments that lasted 30 minutes each session for hemispatial neglect symptoms. These treatments included visual scanning training using a prism and vibration stimulation applied on the left neck extensors and a middle part of the left forearm. In addition, the participants in the CG learned the compensatory approach for ameliorating hemispatial neglect symptoms involving turning a head or trunk. Two dependent occupational therapists who had more than five years of experience conducted all sessions.
Number of participants	24
Duration of follow-up	4 weeks end of intervention
Indirectness	NR
Additional comments	NR

Study arms

robot-assisted left-hand training (N = 12)

conventional therapy (N = 12)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 24)**
Ethnicity Nominal	NR

Characteristic	Study (N = 24)
Comorbidities Nominal	NR
Severity Nominal	NR

Arm-level characteristics

Characteristic	robot-assisted left-hand training (N = 12)	conventional therapy (N = 12)
% Female Nominal	41.7	50
Mean age (SD) months Mean (SD)	69.08 (4.71)	71.58 (3.17)
Time after stroke months Mean (SD)	9.5 (2.61)	9.08 (2.1)

Outcomes

Study timepoints

- Baseline
- 4 week

Dichotomous outcomes

Outcome	robot-assisted left-hand training, Baseline, N = 12	robot-assisted left-hand training, 4 week, N = 12	conventional therapy, Baseline, N = 12	conventional therapy, 4 week, N = 12
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-robot-assisted left-hand training-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Rabadi, 2008

Bibliographic Reference	Rabadi, M. H.; Galgano, M.; Lynch, D.; Akerman, M.; Lesser, M.; Volpe, B. T.; A pilot study of activity-based therapy in the arm motor recovery post stroke: a randomized controlled trial; Clinical Rehabilitation; 2008; vol. 22 (no. 12); 1071-1082

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months) < 4 weeks
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	Not stated/unclear
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement	Mixed

delivered by robotic device	

Study arms

Robot-assissted arm training (N = 10)
Standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of robotic-assisted arm training with the MIT-Manus 5 days per week.

Non-robot arm training (N = 20)
Group 1: standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of occupational therapy 5 days per week. Group 2: standard occupational and physical therapy for 3 hours per day plus 12 additional sessions of 40 minutes of arm ergometry 5 days per week. The 2 groups were combined for analysis.

Outcomes

Study timepoints
- Baseline
- 3 week (Post-intervention, time point unclear)

Dichotomous outcome

Outcome	Robot-assissted arm training, Baseline, N = 10	Robot-assissted arm training, 3 week, N = 10	Non-robot arm training, Baseline, N = 20	Non-robot arm training, 3 week, N = 20
Withdrawal for any reason	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Robot-assissted arm training, Baseline, N = 10	Robot-assissted arm training, 3 week, N = 10	Non-robot arm training, Baseline, N = 20	Non-robot arm training, 3 week, N = 20
No of events				

Continuous outcomes

Outcome	Robot-assissted arm training, Baseline, N = 10	Robot-assissted arm training, 3 week, N = 10	Non-robot arm training, Baseline, N = 20	Non-robot arm training, 3 week, N = 20
Activities of daily living (FIM, including motor and cognition subscale) Final values. Scale range 18-126.Values taken from Cochrane review Mean (SD)	NR (NR)	25.5 (7.2)	NR (NR)	28.3 (6.7)
Arm function (Fugl-Meyer assessment) Change scores. Scale 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	3.1 (8.1)	NR (NR)	3.9 (6.9)
Arm muscle strength (motor Power Scale) Change scores. Scale 0-70. Values as reported in Cochrane review Mean (SD)	NR (NR)	8.3 (7.9)	NR (NR)	1.2 (9.6)

Outcome	Robot-assissted arm training, Baseline, N = 10	Robot-assissted arm training, 3 week, N = 10	Non-robot arm training, Baseline, N = 20	Non-robot arm training, 3 week, N = 20
Spasticity (MAS) Final values. Scale range 0-5. Average calculated for 2 control groups. Mean (SD)	NR (NR)	2.73 (1.29)	NR (NR)	2.29 (1.53)

Activities of daily living (FIM, including motor and cognition subscale) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm muscle strength (motor Power Scale) - Polarity - Higher values are better
Spasticity (MAS) - Polarity - Lower values are better
Also reports shoulder/ elbow and wrist/ hand subscales of FMA, ARAT. Spasticity outcome: OT group: 3.18 (1.4), arm ergometry group: 1.4 (1.07)

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(FIM,includingmotorandcognitionsubscale)-MeanSD-Robot-assissted arm training-Non-robot arm training-t0

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

1 ***Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assissted arm training-Non-robot arm training-t0***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

2

3 ***Continuousoutcomes-Armmusclestrength(motorPowerScale)-MeanSD-Robot-assissted arm training-Non-robot arm training-t0***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

4

5 ***Continuousoutcomes-Spasticity(MAS)-MeanSD-Robot-assissted arm training-Non-robot arm training-t0***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

6

7 ***Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assissted arm training-Non-robot arm training-t0***

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Ranzani, 2020

Bibliographic Reference	Ranzani, R.; Lambercy, O.; Metzger, J. C.; Califfi, A.; Regazzi, S.; Dinacci, D.; Petrillo, C.; Rossi, P.; Conti, F. M.; Gassert, R.; Neurocognitive robot-assisted rehabilitation of hand function: a randomized control trial on motor recovery in subacute stroke; Journal of Neuroengineering & Rehabilitation; 2020; vol. 17 (no. 1); 115

Study details

Secondary publication of another included study- see primary study for details	NA
Other publications associated with this study included in review	NA
Trial name / registration number	NCT02096445
Study location	Switzerland
Study setting	Rehabilitation centre
Study dates	April 2013 and March 2017
Sources of funding	This work was supported by the National Center of Competence in Research on Neural Plasticity and Repair of the Swiss National Science Foundation (NCCR Neuro), the ETH CHIRP1 Research Grant on Cortically-Driven Assistance Adaptation during Sensorimotor Training, the Olga Mayenfisch Stiftung, the ETH Zurich Foundation in collaboration with Hocoma AG, and the Clinica Hildebrand Centro di Riabilitazione Brissago, Switzerland.

Inclusion criteria	Subjects were enrolled in the study if they met the following inclusion criteria: age between 18 and 90 years old, first and only cerebrovascular event, subacute lesion (i.e., occurred not earlier than 6 weeks before recruitment), hemiparesis with arm motor deficit as assessed with a National Institutes of Health Stroke Scale (NIHS S ≥1.
Exclusion criteria	Subjects were excluded if they presented an altered state of consciousness, severe aphasia (Goodglass and Kaplan test < 1), severe cognitive deficits (Levels of Cognitive Functioning-Revised, LCF-R < 6), severe pathologies of the upper limb of traumatic or rheumatic nature, severe pain in the affected arm (≥5 on a visual analogue scale for pain (VASp)), or if they had active pacemakers and other active implants.
Recruitment / selection of participants	Study participants were recruited among inpatients undergoing an intensive interdisciplinary rehabilitation therapy program post stroke.
Intervention(s)	The neurocognitive therapy approach includes sensorimotor and cognitive aspects, all fundamental during the execution of complex tasks and activities of daily life. Focusing on haptic and postural perception, often without vision, subjects are asked to explore objects (e.g. sponges, sticks, springs), discriminate their properties and perceive relative differences. A robotic device is an ideal tool to perform such exercises, as a wide range of haptic stimuli can easily and accurately be rendered in a repeatable and well-controlled manner. The robotic device used in this study can haptically reproduce the same objects and, thereby, motor, sensory and cognitive tasks used in conventional therapy. The objects are rendered via the robotic handles by generating appropriate forces during hand opening/closing and forearm pronosupination, while they are displayed on a screen. Similarly, each 45-min session of robot-assisted therapy included three exercises (selected each day following a predefined plan common to all participants) consisting of up to 30 task repetitions with the robot (each involving multiple movements and interpretation of sensory information), in a maximum of 15 min per exercise. The exercise type, number of task repetitions per exercise and the maximum exercise duration were selected based on pilot tests on subjects with stroke [29] to precisely match therapy type and dose typically performed in conventional therapy. In each exercise, the difficulty level was initially adapted to the subject according to a baseline robotic assessment and continuously updated at the end of each session depending on the subject's performance. An experienced physio- or occupational therapist supervised all the sessions. The tasks were executed either passively (i.e., guided by the therapist/robot) when they only required sensory perception (e.g. of object length or forearm orientation), or actively by the subject (against the resistance of the object/robot) when they required active object manipulation (e.g., stiffness identification).

	Concomitant therapy- In both groups, all the conventional neurocognitive therapy sessions included two or three exercises depending on the session duration (i.e., 30 or 45 min), as typically done in the standard clinical setting. The exercises were performed with the help of the therapist, who progressively adapted the assistance and difficulty level of the exercise (e.g., number of objects, object length or stiffness) depending on his/her evaluation of the subject's ability
Subgroup 1: Severity	Mild (or NIHSS 1-5)
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement	Mixed

delivered by robotic device	
Population subgroups	NA
Comparator	In both groups, all the conventional neurocognitive therapy sessions included two or three exercises depending on the session duration (i.e., 30 or 45 min), as typically done in the standard clinical setting. The exercises were performed with the help of the therapist, who progressively adapted the assistance and difficulty level of the exercise (e.g., number of objects, object length or stiffness) depending on his/her evaluation of the subject's ability
Number of participants	33
Duration of follow-up	post intervention (4 weeks)
Indirectness	NR
Additional comments	NR

Study arms

robot-assisted neurocognitive therapy (N = 17)

conventional neurocognitive therapy (N = 16)

1 **Characteristics**

2 ***Study-level characteristics***

Characteristic	Study (N = 33)
Ethnicity Nominal	NR
Comorbidities Nominal	NR

3

4 ***Arm-level characteristics***

Characteristic	robot-assisted neurocognitive therapy (N = 17)	conventional neurocognitive therapy (N = 16)
% Female Nominal	28.6	38.4
Mean age (SD) Mean (SD)	70 (12.79)	67.46 (11.39)
Severity Mean (SD)	1.36 (0.75)	1.69 (1.03)
Time after stroke weeks Mean (SD)	3.14 (1.51)	3.08 (1.32)

5

Outcomes

Study timepoints

- Baseline
- 4 week (post intervention)
- 32 week

Continuous outcomes

Outcome	robot-assisted neurocognitive therapy, Baseline, N = 17	robot-assisted neurocognitive therapy, 4 week, N = 14	robot-assisted neurocognitive therapy, 32 week, N = 14	conventional neurocognitive therapy, Baseline, N = 16	conventional neurocognitive therapy, 4 week, N = 13	conventional neurocognitive therapy, 32 week, N = 13
Arm function (Fugl Meyer UE) 0-66, change scores Mean (SD)	50.14 (12.5)	7.14 (5.72)	8.64 (7.42)	50.85 (15)	6.85 (5.34)	8.08 (8.32)
Spasticity (Ashworth MAS) 0-4, change score Mean (SD)	1.29 (1.77)	0.07 (2.37)	-0.21 (2.36)	2.15 (2.94)	-1.54 (2.91)	-1.31 (3.12)

Arm function (Fugl Meyer UE) - Polarity - Higher values are better
Spasticity (Ashworth MAS) - Polarity - Lower values are better

Dichotomous outcomes

Outcome	robot-assisted neurocognitive therapy, Baseline, N = 17	robot-assisted neurocognitive therapy, 4 week, N = 17	robot-assisted neurocognitive therapy, 32 week, N = 17	conventional neurocognitive therapy, Baseline, N = 16	conventional neurocognitive therapy, 4 week, N = 16	conventional neurocognitive therapy, 32 week, N = 16
Withdrawal for any reason intervention reasons = 1 fatigue, 1 unrelated renal failure, 1 lack of motivation. Reasons control = 1 cognitive deficits, 1 lack of motivation No of events	n = 0 ; % = 0	n = 3 ; % = 17.6	n = 5 ; % = 29.4	n = 0 ; % = 0	n = 2 ; % = 12.5	n = 5 ; % = 31.3

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t32

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t32

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-robot-assisted neurocognitive therapy-conventional neurocognitive therapy-t32

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Remy-Neris, 2021

Bibliographic Reference	Remy-Neris, O.; Le Jeannic, A.; Dion, A.; Medee, B.; Nowak, E.; Poiroux, E.; Durand-Zaleski, I.; Team*, R. E. M. Investigative; Additional, Mechanized Upper Limb Self-Rehabilitation in Patients With Subacute Stroke: The REM-AVC Randomized Trial; Stroke; 2021; vol. 52 (no. 6); 1938-1947

Study details

Secondary publication of another included	NR

study- see primary study for details	
Other publications associated with this study included in review	NR
Trial name / registration number	NCT01383512
Study location	France
Study setting	21 inpatient rehabilitation centres
Study dates	June 2011 to December 2016
Sources of funding	This study was supported by the French Ministry of Health: EMREM_AVC CHU BREST 20 220.
Inclusion criteria	The inclusion criteria were as follows: aged 18 to 81 years old, diagnosis of hemorrhagic or ischemic middle cerebral artery stroke 3 weeks to 3 months previously, and an FMA UE8 score between 10 and 40 points.
Exclusion criteria	Exclusion criteria were as follows: pain in the affected shoulder >3/10 on a visual analogue scale, a Boston Diagnostic Aphasia Examination9 score ≤3 points, fatigue or visual impairment that would prevent participation in an additional daily hour of therapy, and an inability to sit independently.
Recruitment / selection of participants	Patients were enrolled by an allocated physician at each site via a secure, web-based, centralized data entry system that ensured all inclusion and exclusion criteria were respected.
Intervention(s)	The ArmeoSpring exoskeleton device (Hocoma, Inc, Zurich, Switzerland) was used for the gravity-supported, games-based self-rehabilitation, following the response to a call to tender. This is a mechanized, nonactuated exoskeleton that supports the weight of the arm by means of springs. It records joint angles and the position of the end effector (handheld by the user) in real time. It is designed to train shoulder and elbow movements, pronation and supination, and grip-release through participation in games displayed on a screen. The games are conceived to challenge movement distance or speed or a combination of both. The workspace required for the games is personalized for each user (by the therapist) as the maximum space in which they can actively reach the limits of the virtual environment.

	A therapist was present during the first 4 sessions; for the remaining sessions, the therapist set the patient up in the device, adjusted the device parameters, and programmed the exercises, but the participant then trained independently. concomitant therapy- The study involved usual rehabilitation for all participants, followed by an additional daily hour of self-rehabilitation (two 30-minute sessions) consisting of either gravity-supported, games-based training using an exoskeleton (for the Exo group) or basic stretching and active exercises (for the control group) over a period of 4 weeks. This dose of self-rehabilitation was chosen according to therapist's opinions of the amount feasible in the context of multidisciplinary rehabilitation and post stroke fatigue. Participating therapists (physiotherapists and occupational therapists) received specific training in the use of the device for the purposes of the study and in the control self-rehabilitation during a 2-day training program. Performance of self-rehabilitation was encouraged by the therapist in charge of each patient who recorded attendance and session duration. All participants underwent the usual rehabilitation provided in each center, 5 days per week. UL rehabilitation time was standardized across centers to a maximum of 1.5 hours per day during the trial.
Subgroup 1: Severity	Moderate (or NIHSS 5-14)
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks

Subgroup 7: Level of supervision	Unsupervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	The control group performed their self-rehabilitation in the rehabilitation room. A 2×2-m instruction poster with written and photographic instructions of stretches and active exercises was fixed to a wall (Data Supplement). Participants were instructed to perform 10 minutes of stretching (5-second stretches of the main muscles that shorten after stroke) and 20 minutes of active exercises (10 repetitions of each exercise) that involved simple movements of the UL joints through range and no functional exercises. Exercises involving range of motion could be progressed in terms of distance and height, but no formal method of progression was determined. A therapist was present throughout the first 4 sessions: for the remaining sessions, they checked the participant's attendance, recommended exercises to be performed, provided encouragement to continue if the patient stopped exercising, but did not supervise the exercise program.
Number of participants	215
Duration of follow-up	End of intervention
Indirectness	NR
Additional comments	NR

Study arms

Robot therapy with Armeo Spring (N = 107)

Conventional therapy (N = 108)

Characteristics

Study-level characteristics

Characteristic	Study (N = 215)
Ethnicity Nominal	NR
Comorbidities Nominal	NR

Arm-level characteristics

Characteristic	Robot therapy with Armeo Spring (N = 107)	Conventional therapy (N = 108)
% Female Nominal	37.38	32.41
Mean age (SD) Mean (SD)	58.08 (14.05)	58.53 (13.27)
Severity NIHSS Mean (SD)	5.04 (2.36)	5.4 (2.45)

Characteristic	Robot therapy with Armeo Spring (N = 107)	Conventional therapy (N = 108)
Time after stroke days Mean (SD)	55.67 (21.6)	53.93 (22.68)

Outcomes

Study timepoints

- Baseline
- 30 day (post intervention)
- 12 month

continuous outcomes

Outcome	Robot therapy with Armeo Spring, Baseline, N = 107	Robot therapy with Armeo Spring, 30 day, N = 105	Robot therapy with Armeo Spring, 12 month, N = 97	Conventional therapy, Baseline, N = 108	Conventional therapy, 30 day, N = 103	Conventional therapy, 12 month, N = 97
Arm function (Fugel myer UE) 0-66, change score Mean (SD)	25.87 (9.01)	13.32 (9.03)	23.44 (11.09)	26.36 (9.96)	11.78 (8.84)	22.41 (10.53)
person/particpant health related quality of life (EQ5D)	53.43 (20.17)	NR (NR)	14.41 (19.86)	50.13 (19.82)	NR (NR)	19.08 (22.8)

Outcome	Robot therapy with Armeo Spring, Baseline, N = 107	Robot therapy with Armeo Spring, 30 day, N = 105	Robot therapy with Armeo Spring, 12 month, N = 97	Conventional therapy, Baseline, N = 108	Conventional therapy, 30 day, N = 103	Conventional therapy, 12 month, N = 97
0-100 (change score) from 0-12 months FU Mean (SD)						
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-hand function domain) 0-100, change score Mean (SD)	12.19 (20.54)	14.79 (24.41)	37.8 (31.22)	7.24 (12.58)	14.99 (21.43)	35.27 (32.24)
Activties of daily living (functional independence measure) 13-91, change score Mean (SD)	98.35 (17.67)	10.81 (9.38)	18.51 (13.3)	99.95 (16.7)	10.68 (10.02)	18.65 (14.75)

1 Arm function (Fugel myer UE) - Polarity - Higher values are better
2 person/particpant health related quality of life (EQ5D) - Polarity - Higher values are better
3 Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale-hand function domain) - Polarity - Higher values are better
4 Activties of daily living (functional independence measure) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot therapy with Armeo Spring, Baseline, N = 107	Robot therapy with Armeo Spring, 30 day, N = 107	Robot therapy with Armeo Spring, 12 month, N = 107	Conventional therapy, Baseline, N = 108	Conventional therapy, 30 day, N = 108	Conventional therapy, 12 month, N = 108
Adverse events (injuries and pain) No of events	n = 0 ; % = 0	n = 45 ; % = 42.1	n = NR ; % = NR	n = 0 ; % = 0	n = 59 ; % = 54.6	n = NR ; % = NR
Other reported adverse events serious events No of events	n = 0 ; % = 0	n = 4 ; % = 3.7	n = NR ; % = NR	n = 0 ; % = 0	n = 5 ; % = 4.6	n = NR ; % = NR
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 1 ; % = 0.9	n = 3 ; % = 2.8	n = 0 ; % = 0	n = 4 ; % = 3.7	n = 3 ; % = 2.8

Adverse events (injuries and pain) - Polarity - Lower values are better

Other reported adverse events - Polarity - Lower values are better

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-handfunctiondomain)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome no blinding)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Activtiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armfunction(FugeImyerUE)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents(injuriesandpain)-NoOfEvents-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Otherreportedadverseevents-NoOfEvents-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy with Armeo Spring-Conventional therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armfunction(FugelmyerUE)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-person/particpanthealthrelatedqualityoflife(EQ5D)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to measurement of outcome no blinding and reporting only at 12 months)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-handfunctiondomain)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome no blinding)*
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Activtiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy with Armeo Spring-Conventional therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy with Armeo Spring-Conventional therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Rodgers, 2019

Bibliographic Reference	Rodgers, H.; Bosomworth, H.; Krebs, H. I.; van Wijck, F.; Howel, D.; Wilson, N.; Aird, L.; Alvarado, N.; Andole, S.; Cohen, D. L.; Dawson, J.; Fernandez-Garcia, C.; Finch, T.; Ford, G. A.; Francis, R.; Hogg, S.; Hughes, N.; Price, C. I.; Ternent, L.; Turner, D. L.; Vale, L.; Wilkes, S.; Shaw, L.; Robot assisted training for the upper limb after stroke (RATULS): a multicentre randomised controlled trial; Lancet; 2019; vol. 394 (no. 10192); 51-62

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	Rodgers H, Bosomworth H, Krebs HI, van Wijck F, Howel D, Wilson N, Finch T, Alvarado N, Ternent L, Fernandez-Garcia C, Aird L, Andole S, Cohen DL, Dawson J, Ford GA, Francis R, Hogg S, Hughes N, Price CI, Turner DL, Vale L, Wilkes S, Shaw L. Robot-assisted training compared with an enhanced upper limb therapy programme and with usual care for upper limb functional limitation after stroke: the RATULS three-group RCT. Health Technol Assess. 2020 Oct;24(54):1-232. doi: 10.3310/hta24540. PMID: 33140719; PMCID: PMC7682262.

	Fernandez-Garcia C, Ternent L, Homer TM, Rodgers H, Bosomworth H, Shaw L, Aird L, Andole S, Cohen D, Dawson J, Finch T, Ford G, Francis R, Hogg S, Hughes N, Krebs HI, Price C, Turner D, Van Wijck F, Wilkes S, Wilson N, Vale L. Economic evaluation of robot-assisted training versus an enhanced upper limb therapy programme or usual care for patients with moderate or severe upper limb functional limitation due to stroke: results from the RATULS randomised controlled trial. BMJ Open. 2021 May 25;11(5):e042081. doi: 10.1136/bmjopen-2020-042081. PMID: 34035087; PMCID: PMC8154983.
Trial name / registration number	ISRCTN69371850.
Study location	UK
Study setting	Four National Health Service (NHS) centres in the UK. Each centre comprised a stroke service in an NHS hospital with an MIT-Manus robotic gym system (InMotion commercial version, Interactive Motion Technologies, Watertown, MA, USA), plus stroke services in adjacent NHS Trusts and community services.
Study dates	Between April 14, 2014, and April 30, 2018
Sources of funding	National Institute for Health Research Health Technology Assessment Programme.
Inclusion criteria	Study participants were adults (age ≥18 years) with moderate or severe upper limb functional limitation (Action Research Arm Test [ARAT] score 0–39) 9 as a result of first-ever stroke that had occurred between 1 week and 5 years before randomisation.
Exclusion criteria	Exclusion criteria were other notable impairment in the upper limb affected by stroke; other diagnosis that might interfere with rehabilitation or outcome assessments; previous use of the robotic gym system or other arm rehabilitation robot; participation in another upper limb rehabilitation trial; and previous enrolment in this study. Participants were recruited from stroke units, outpatient clinics, day hospitals, community rehabilitation services, local stroke clubs, and primary care.
Recruitment / selection of participants	Randomisation was done through a central independent web-based service hosted by Newcastle University Clinical Trials Unit. Participants were randomly assigned 1:1:1 to receive robot-assisted training, an EULT programme, or usual care using permuted block sequences stratified according to centre, time since stroke, and severity of upper limb functional limitation (ARAT score).9 The sequences were prepared by an independent statistician before the start of enrolment.
Intervention(s)	The robot-assisted training programme integrated training with all three modules of the MIT-Manus robotic gym (shoulder–elbow module, wrist module, hand module integrated on to the shoulder–elbow module). The MIT-Manus robotic gym recorded data on the robot-assisted training sessions content.

	Concomitant therapy - Robot-assisted training and EULT programmes were delivered at the same frequency and duration: 45 min of face-to-face therapy, three times per week for 12 weeks. The same therapists and therapy assistants delivered both interventions at each centre. Robot-assisted training and EULT were delivered in addition to usual post-stroke care.
Subgroup 1: Severity	Moderate (or NIHSS 5-14)
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Population subgroups	NR
Comparator	The 2 control groups have been combined for the purposes of this review in align with the Cochrane review. EULT - The EULT programme was designed to reflect best practice using repetitive functional task practice to work towards participant-centred goals. Therapists recorded data on the content of EULT sessions. Robot-assisted training and EULT programmes were delivered at the same frequency and duration: 45 min of face-to-face therapy, three times per week for 12 weeks. Usual care - Participants assigned to usual care received usual NHS care, which was provided by their local clinical service. The English national quality standard is that patients with stroke should be offered a minimum of 45 min of each appropriate therapy that is required, for a minimum of 5 days per week, at a level that enables the patient to meet their rehabilitation goals for as long as they are continuing to benefit from therapy and as long as they are able to tolerate it.
Number of participants	770
Duration of follow-up	3 months
Indirectness	NR
Additional comments	NR

Study arms

Robot assisted training (N = 257)

Enhanced UL therapy and usual care (N = 513)

Characteristics

Study-level characteristics

Characteristic	Study (N = 770)
Ethnicity Nominal	NR
Comorbidities Nominal	NR

Arm-level characteristics

Characteristic	Robot assisted training (N = 257)	Enhanced UL therapy and usual care (N = 513)
% Female Nominal	39	39.1
Mean age (SD) Mean (SD)	59.9 (13.5)	60.9 (13.5)
Severity NIHSS Mean (SD)	5.6 (3.2)	5.7 (3.2)

Characteristic	Robot assisted training (N = 257)	Enhanced UL therapy and usual care (N = 513)
Time after stroke days Median (IQR)	233 (102 to 549)	NR (NR to NR)

Outcomes

Study timepoints

- Baseline
- 3 month
- 6 month

Continuous ouctomes

Outcome	Robot assisted training, Baseline, N = 257	Robot assisted training, 3 month, N = 232	Robot assisted training, 6 month, N = 221	Enhanced UL therapy and usual care, Baseline, N = 513	Enhanced UL therapy and usual care, 3 month, N = 437	Enhanced UL therapy and usual care, 6 month, N = 404
Activties of dailiy living (Barthel index) 0-100, final values Mean (SD)	14.5 (3.8)	15.5 (3.4)	15.6 (3.4)	14.4 (4)	15.3 (3.6)	15.7 (3.6)
Arm function (Fugl Meyer UE) 0-126, final values	68.9 (16.5)	76.6 (22.1)	78.2 (22.8)	69 (18)	76.1 (23.2)	78.7 (23.7)

Outcome	Robot assisted training, Baseline, N = 257	Robot assisted training, 3 month, N = 232	Robot assisted training, 6 month, N = 221	Enhanced UL therapy and usual care, Baseline, N = 513	Enhanced UL therapy and usual care, 3 month, N = 437	Enhanced UL therapy and usual care, 6 month, N = 404
Mean (SD)						
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale hand function) 0-100, final value. intervention N = 213, control N = 395 Mean (SD)	NR (NR)	15.5 (24.4)	15.7 (25.2)	NR (NR)	18.1 (25.9)	16.8 (25.1)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale - mobility) 0-100, final value intervention N = 213, control N = 395 Mean (SD)	NR (NR)	61.6 (25.1)	61.7 (24.8)	NR (NR)	63.9 (24)	63.4 (23.8)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale ADLs) 0-100, final value intervention N = 213, control N = 395 Mean (SD)	NR (NR)	50.8 (22.5)	50.4 (22.3)	NR (NR)	53.5 (21)	52.2 (22)
Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scalesocial	NR (NR)	47.7 (24.7)	47 (25.9)	NR (NR)	49.6 (23.4)	50 (24.1)

Outcome	Robot assisted training, Baseline, N = 257	Robot assisted training, 3 month, N = 232	Robot assisted training, 6 month, N = 221	Enhanced UL therapy and usual care, Baseline, N = 513	Enhanced UL therapy and usual care, 3 month, N = 437	Enhanced UL therapy and usual care, 6 month, N = 404
participation) 0-100, final values. intervention N = 210, control N = 394 Mean (SD)						
Person/participant generic health related quality of life (EQ5D)) 0-1, final values Mean (SD)	0.36 (0.26)	0.45 (0.27)	0.46 (0.29)	0.38 (0.26)	0.45 (0.27)	0.5 (0.3)

1 Activties of dailiy living (Barthel index) - Polarity - Higher values are better
2 Arm function (Fugl Meyer UE) - Polarity - Higher values are better
3 Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale hand function) - Polarity - Higher values are better
4 Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale - mobility) - Polarity - Higher values are better
5 Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scale ADLs) - Polarity - Higher values are better
6 Stroke-specific Patient Reported Outcome Measure (Stroke Impact Scalesocial participation) - Polarity - Higher values are better
7 Person/participant generic health related quality of life (EQ5D)) - Polarity - Higher values are better

dichotomous outcomes

Outcome	Robot assisted training, Baseline, N = 257	Robot assisted training, 3 month, N = 257	Robot assisted training, 6 month, N = 257	Enhanced UL therapy and usual care, Baseline, N = 513	Enhanced UL therapy and usual care, 3 month, N = 513	Enhanced UL therapy and usual care, 6 month, N = 513
withdrawal due to any reason No of events	n = 0 ; % = 0	n = 18 ; % = 7	n = 11 ; % = 4.2	n = 0 ; % = 0	n = 44 ; % = 8.57	n = 38 ; % = 7.4
adverse events (cardiovascular) intervention N = 233, control N = 443, 6 months intervention = 223, control = 412 No of events	n = 0 ; % = 0	n = 5 ; % = 1.9	n = 2 ; % = 0.9	n = 0 ; % = 0	n = 2 ; % = 0.4	n = 2 ; % = 0.5
Adverse events general 3 months- intervention N = 233, control N = 443, 6 months intervention = 223, control = 412 No of events	n = 0 ; % = 0	n = 46 ; % = 19.7	n = 44 ; % = 19.7	n = 0 ; % = 0	n = 78 ; % = 17.6	n = 84 ; % = 20.4

withdrawal due to any reason - Polarity - Lower values are better

adverse events (cardiovascular) - Polarity - Lower values are better

Adverse events general - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

dichotomousoutcomes-withdrawalduetoanyreason-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Activtiesofdailiyliving(Barthelindex)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Armfunction(FuglMeyerUE)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScalehandfunction)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScalesocialparticipation)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScaleADLs)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-mobility)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Person/participantgenerichealthrelatedqualityoflife(EQ5D))-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Person/participantgenerichealthrelatedqualityoflife(EQ5D))-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScalesocialparticipation)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScaleADLs)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScale-mobility)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Stroke-specificPatientReportedOutcomeMeasure(StrokeImpactScalehandfunction)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to measurement of the outcome as no blinding and self reported outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Armfunction(FuglMeyerUE)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousouctomes-Activtiesofdailiyliving(Barthelindex)-MeanSD-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

dichotomousoutcomes-Adverseeventsgeneral-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

dichotomousoutcomes-Adverseeventsgeneral-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

dichotomousoutcomes-adverseevents(cardiovascular)-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

dichotomousoutcomes-adverseevents(cardiovascular)-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

dichotomousoutcomes-withdrawalduetoanyreason-NoOfEvents-Robot assisted training-Enhanced UL therapy and usual care-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Rodgers, 2020

Bibliographic Reference	Rodgers, H.; Bosomworth, H.; Krebs, H. I.; van Wijck, F.; Howel, D.; Wilson, N.; Finch, T.; Alvarado, N.; Ternent, L.; Fernandez-Garcia, C.; Aird, L.; Andole, S.; Cohen, D. L.; Dawson, J.; Ford, G. A.; Francis, R.; Hogg, S.; Hughes, N.; Price, C. I.; Turner, D. L.; Vale, L.; Wilkes, S.; Shaw, L.; Robot-assisted training compared with an enhanced upper limb therapy programme and with usual care for upper limb functional limitation after stroke: the RATULS three-group RCT; Health Technology Assessment (Winchester, England); 2020; vol. 24 (no. 54); 1-232

Study details

Secondary publication of another included study- see primary study for details	Rodgers H, Bosomworth H, Krebs HI, van Wijck F, Howel D, Wilson N, Aird L, Alvarado N, Andole S, Cohen DL, Dawson J, Fernandez-Garcia C, Finch T, Ford GA, Francis R, Hogg S, Hughes N, Price CI, Ternent L, Turner DL, Vale L, Wilkes S, Shaw L. Robot assisted training for the upper limb after stroke (RATULS): a multicentre randomised controlled trial. Lancet. 2019 Jul 6;394(10192):51-62. doi: 10.1016/S0140-6736(19)31055-4. Epub 2019 May 22. PMID: 31128926; PMCID: PMC6620612.
Other publications associated with this study included in review	Fernandez-Garcia C, Ternent L, Homer TM, Rodgers H, Bosomworth H, Shaw L, Aird L, Andole S, Cohen D, Dawson J, Finch T, Ford G, Francis R, Hogg S, Hughes N, Krebs HI, Price C, Turner D, Van Wijck F, Wilkes S, Wilson N, Vale L. Economic evaluation of robot-assisted training versus an enhanced upper limb therapy programme or usual care for patients with moderate or severe upper limb functional limitation due to stroke: results from the RATULS randomised controlled trial. BMJ Open. 2021 May 25;11(5):e042081. doi: 10.1136/bmjopen-2020-042081. PMID: 34035087; PMCID: PMC8154983.

Sale, 2014

Bibliographic Reference	Sale, Patrizio; Franceschini, Marco; Mazzoleni, Stefano; Palma, Enzo; Agosti, Maurizio; Posteraro, Federico; Effects of upper limb robot-assisted therapy on motor recovery in subacute stroke patients; Journal of neuroengineering and rehabilitation; 2014; vol. 11 (no. 1); 1-8

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Mazzoleni S, Buono L, Dario P, Posteraro F. Upper limb robot-assisted therapy in subacute and chronic stroke patients: preliminary results on initial exposure based on kinematic measures. 5th IEEE RAS and EMBS International Conference on Biomedical Robotics and Biomechatronics, BioRob; 12-15 August, 2014. 2014:265-9. [MEDLINE: 4006; 21551774]

	Sale P, Mazzoleni S, Lombardi V, Galafate D, Massimiani MP, Posteraro F, et al. Recovery of hand function with robot-assisted therapy in acute stroke patients: a randomized-controlled trial. *International Journal of Rehabilitation Research* 2014;37(3):236-42. [MEDLINE: 4901; 03425282]
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

1

Study arms

Robot-assisted therapy (N = 26)
30 sessions of robot-assisted therapy (5 days a week for 6 weeks).

Conventional rehabilitative treatment (N = 27)
30 sessions (5 days a week for 6 weeks)

Outcomes

Study timepoints
- Baseline
- 6 week (Post-intervention)

Dichotomous outcome

Outcome	Robot-assisted therapy, Baseline, N = 26	Robot-assisted therapy, 6 week, N = 26	Conventional rehabilitative treatment, Baseline, N = 27	Conventional rehabilitative treatment, 6 week, N = 27
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot-assisted therapy, Baseline, N = 26	Robot-assisted therapy, 6 week, N = 26	Conventional rehabilitative treatment, Baseline, N = 27	Conventional rehabilitative treatment, 6 week, N = 27
Arm function (Fugl-Meyer assessment) Change scores. Scale range 0-66. Values as reported in Cochrane review. Mean (SD)	26.81 (11.43)	8.7 (7.5)	20.33 (16.01)	3.6 (10.7)
Arm muscle strength (Motricity Index) Change scores. Scale range 0-100. Values as reported in Cochrane review. Mean (SD)	43.88 (24.77)	13.9 (15.5)	30.3 (33.38)	9.3 (21.7)
Spasticity (MAS)- shoulder Final values. Scale range 0-5 Mean (SD)	1.15 (1.16)	0.73 (1.08)	1.19 (1)	1.15 (1.17)
Spasticity (MAS)- elbow Final values. Scale range 0-5 Mean (SD)	1.12 (1.07)	0.73 (0.96)	0.85 (0.91)	0.93 (0.96)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm muscle strength (Motricity Index) - Polarity - Higher values are better
Spasticity (MAS)- shoulder - Polarity - Lower values are better
Spasticity (MAS)- elbow - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Spasticity(MAS)-elbow-MeanSD-Robot-assisted therapy-Conventional rehabilitative treatment-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(MAS)-shoulder-MeanSD-Robot-assisted therapy-Conventional rehabilitative treatment-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot-assisted therapy-Conventional rehabilitative treatment-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted therapy-Conventional rehabilitative treatment-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted therapy-Conventional rehabilitative treatment-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Sale, 2014

Bibliographic Reference	Sale, Patrizio; Mazzoleni, Stefano; Lombardi, Valentina; Galafate, Daniele; Massimiani, Maria P.; Posteraro, Federico; Damiani, Carlo; Franceschini, Marco; Recovery of hand function with robot-assisted therapy in acute stroke patients: a randomized-controlled trial; International journal of rehabilitation research; 2014; vol. 37 (no. 3); 236-242

Study details

Secondary publication of another included study- see primary study for details	Sale et al. Effects of upper limb robot-assisted therapy on motor recovery in subacute stroke patients. J Neuroeng Rehabil. 2014; 11: 104.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

1

2

Singh, 2021

Bibliographic Reference	Singh, N.; Saini, M.; Kumar, N.; Srivastava, M. V. P.; Mehndiratta, A.; Evidence of neuroplasticity with robotic hand exoskeleton for post-stroke rehabilitation: a randomized controlled trial; Journal of Neuroengineering & Rehabilitation; 2021; vol. 18 (no. 1); 76

Study details

Secondary publication of another included study- see primary study for details	NR
Trial name / registration number	ISRCTN95291802
Study location	India
Study setting	outpatient clinic
Study dates	July-2016 to January-2019
Sources of funding	This work was financially supported by SERB, DST India (YSS/2015/000697) and IIT Delhi, MFIRP (Project no. AI-19).
Inclusion criteria	Patients were enrolled based on inclusion-criteria, age 18–70 years, having ischemic / hemorrhagic stroke within 3–24 months, Mini-Mental Scale (MMS)=24–30; Brunnstrom stage (BS)=3–5; Modifed Ashworth Scale (MAS)=1, 1+, 2
Exclusion criteria	Patients with contra-indication to Transcranial Magnetic Stimulation (TMS), no detectable Electromyogram (EMG) activity and any other progressive neurological or cognitive disorders were excluded from the study.
Recruitment / selection of participants	More than 300 patients (n>300) were screened in the out-patient clinic of the Department of Neurology, AIIMS, New-Delhi over three years from July-2016 to January-2019. Stroke diagnosis was established clinically in all the patients
Intervention(s)	An electromechanical robotic-exoskeleton was developed for rehabilitation of wrist-joint and fingers-joint. Stages of motion sequence were: wrist at the neutral position, finger extension (baseline position) → wrist extension finger flexion (final

	position) → back to wrist flexion, finger extension (towards baseline position); with a constant speed (28 degrees/second) for all the patients. All sessions were given at the hospital set-up under the supervision of an expert clinician. Each 45 min robotic-therapy session consisted of approximately 250 trials of 10 s each, excluding the setup time, breaks, donning and doing of the exoskeleton or consultation which was an additional 10–15 min. Patients were advised to take 5 min break for rest in between the therapy-session if there is a feeling of pain or fatigue, this time was then added to the total therapy time, keeping the active therapy session to 45 min consistently. Robot therapy sessions were conducted for 45 min per day for 5 days a week for 4 weeks. Patient hands were stabilized in the exoskeleton device with the velcro straps in the neutral position and therapy required to extend the wrist in a neutral position only (with no ulnar/radial deviation). The device is actively initiated by Electromyogram (EMG) activity of EDC muscle with robot motion-triggered only if the EMG thresholds (set with the consensus of the therapist at the time of first therapy sitting) are crossed and it provides an interactive adaptive performance visual biofeedback in real-time. At baseline position, the patient tries to extend the wrist voluntarily for the first three seconds after the green LED cue. If the EMG crosses the predefined threshold, the exoskeleton will be triggered for an assisted wrist extension and finger flexion movement. Once it reaches the final position, the exoskeleton then assists the patient's hand back to the baseline position, wrist flexion with finger extension.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks

Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	The conventional therapy session was conducted for 45 min per day for 5 days a week for 4 weeks. The type of activity, intensity and frequency was based on the baseline clinical presentation of the patient as reflected by clinical scales (MAS, FMA, BI, BS, and Range of motion).
Number of participants	23
Duration of follow-up	post intervention (4 weeks)
Indirectness	NR
Additional comments	NR

Study arms

Robotic-therapy Group (N = 13)

Conventional therapy (N = 14)

1 **Characteristics**

2 ***Study-level characteristics***

Characteristic	Study (N = 23)
Ethnicity Nominal	NR
Comorbidities Nominal	NR
Severity Nominal	NR

3

4 ***Arm-level characteristics***

Characteristic	Robotic-therapy Group (N = 13)	Conventional therapy (N = 14)
% Female Nominal	NR	NR
Mean age (SD) Mean (SD)	41.1 (12.8)	42.7 (9.3)
Time after stroke months Mean (SD)	13.8 (9.1)	10.3 (5)

5

Outcomes

Study timepoints

- Baseline
- 4 week

Continuous outcomes

Outcome	Robotic-therapy Group, Baseline, N = 13	Robotic-therapy Group, 4 week, N = 12	Conventional therapy, Baseline, N = 14	Conventional therapy, 4 week, N = 11
Activities of daily living (barthel index) 0-100, final value Mean (SD)	74.1 (12.4)	89.1 (7.9)	69.5 (12.9)	82.7 (14.3)
Arm function (Fugl Meyer UE) 0-66, final value Mean (SD)	36 (7.7)	50.2 (6.5)	37.4 (9.1)	45.4 (9.7)
Spastcity outcome - Modified ashworth scale 0-4, final value Mean (SD)	1.75 (0.2)	1.29 (0.2)	1.86 (0.5)	1.59 (0.6)

Activities of daily living (barthel index) - Polarity - Higher values are better
Arm function (Fugl Meyer UE) - Polarity - Higher values are better
Spastcity outcome - Modified ashworth scale - Polarity - Lower values are better

Dichotomous outcomes

Outcome	Robotic-therapy Group, Baseline, N = 13	Robotic-therapy Group, 4 week, N = 13	Conventional therapy, Baseline, N = 14	Conventional therapy, 4 week, N = 14
withdrawal due to any reason No of events	n = 0 ; % = 0	n = 1 ; % = 7.6	n = 0 ; % = 0	n = 3 ; % = 21.4

withdrawal due to any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(barthelindex)-MeanSD-Robotic-therapy Group-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing outcome data)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-withdrawalduetoanyreason-NoOfEvents-Robotic-therapy Group-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing outcome data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-Robotic-therapy Group-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing outcome data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spastcityoutcome-Modifiedashworthscale-MeanSD-Robotic-therapy Group-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to missing outcome data)*
Overall bias and Directness	Overall Directness	Directly applicable

Straudi, 2020

Bibliographic Reference	Straudi, S.; Baroni, A.; Mele, S.; Craighero, L.; Manfredini, F.; Lamberti, N.; Maietti, E.; Basaglia, N.; Effects of a Robot-Assisted Arm Training Plus Hand Functional Electrical Stimulation on Recovery After Stroke: A Randomized Clinical Trial; Archives of Physical Medicine & Rehabilitation; 2020; vol. 101 (no. 2); 309-316

Study details

Secondary publication of another included study- see primary study for details	NR

Other publications associated with this study included in review	NR
Trial name / registration number	(NCT02267798)
Study location	italy
Study setting	Inpatient Rehabilitation University Hospital
Study dates	NR
Sources of funding	NR
Inclusion criteria	Inclusion criteria were: males and females, aged 18-80 years with diagnosis of first, single unilateral ischemic stroke verified by brain imaging <8 weeks. To be enrolled in the study patients had to have an upper limb motor impairment defined by an upper extremity score >11 and <55 on the Fugl-Meyer Assessment (FMA-UE).
Exclusion criteria	Patients were excluded if they presented with neurological conditions in addition to stroke that may affect motor function, other medical conditions likely to interfere with the ability to safely complete the study protocol, impaired cognitive functioning (score <21 on the Mini Mental Status Examination), or severe upper-limb pain defined as >7 on the Visual Analogue Scale.
Recruitment / selection of participants	NR
Intervention(s)	The experimental group received 1 hour and 40 minutes of hand FES+ RAT for each session (5 times/week over 6 weeks). Specifically, a 40 minute-session of hand FES was delivered through a battery-powered programmable stimulator and a forearm-wrist-hand orthosis containing 5 electrodes positioned to provide reliable activation of the following muscles: extensor digitorum communis, extensor pollicis brevis, flexor pollicis longus, flexor digitorum superficialis, and thenar muscles (H200, Bioness, CA). The intensity of stimulation was set to a level that provided comfortable and consistent activation of the extensor and flexor muscles to achieve whole hand opening and functional grasping. Participants were instructed to coordinate their actions with the pre-timed stimulation patterns programmed in the device so as to synchronize the user's intention with FES assistance. Although the stimulation cycles were fixed, participants needed to engage actively in the tasks to produce the synergistic muscle actions throughout the upper limb required for effective task performance. The therapist set up activities to involve each subject in functional exercises specific to their personal needs, such as

	reaching, grasping, holding and releasing or daily activities with upper limb engagement. The voluntary contraction during electrical stimulation increases motor cortical excitability in the agonist muscle. After FES training, patients received 60 minutes of RAT with an end-effector device (Reo Therapy System, Motorika Medical Ltd, Israel) which focused on repetitive tasks that incorporate multidirectional reaching actions. In this robot-assisted therapy a robot manipulator applied forces to the paretic arm during goal-directed movements. During the session the patient's affected hand was placed on or strapped onto a robotic arm and she/he was instructed to either actively reach predefined reach points, or to be guided while the robotic arm led the arm towards these reach points. Concomitant therapy - addition to arm rehabilitation, all patients received multidisciplinary rehabilitation based on an individualized approach.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement	Active assisted movement

delivered by robotic device	
Population subgroups	NR
Comparator	the control group received 1 hour and 40 minutes of conventional therapy (5 times/week over 6 weeks). The control group received the same time of conventional arm therapy (100 minutes). Specific exercises for the affected upper limb included active, passive and sensory exercises or functional tasks.
Number of participants	40
Duration of follow-up	end of treatment - 6 weeks
Indirectness	NR

Study arms

Robot-assisted arm therapy and hand 11 functional electrical stimulation (N = 20)

intensive conventional therapy (N = 20)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 39)**
Ethnicity Nominal	NR

Characteristic	Study (N = 39)
Comorbidities Nominal	NR
Severity Nominal	NR

Arm-level characteristics

Characteristic	Robot-assisted arm therapy and hand 11 functional electrical stimulation (N = 20)	intensive conventional therapy (N = 20)
% Female Nominal	36.8	40
Mean age (SD) Mean (SD)	NR (NR)	NR (NR)
Mean age (SD) Median (IQR)	68 (56 to 71)	68 (58.5 to 73)
Time after stroke Median (IQR)	39 (21 to 62)	32.5 (20 to 51)

Outcomes

Study timepoints

- Baseline
- 6 week

dichotomous outcomes

Outcome	Robot-assisted arm therapy and hand 11 functional electrical stimulation, Baseline, N = 20	Robot-assisted arm therapy and hand 11 functional electrical stimulation, 6 week, N = 20	intensive conventional therapy, Baseline, N = 20	intensive conventional therapy, 6 week, N = 20
Withdrawal for any reason Medical complications unrelated to interventions No of events	n = 0 ; % = 0	n = 1 ; % = 5	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm therapy and hand 11 functional electrical stimulation-intensive conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(due to analysis used and bias due to deviations from the intended interventions)*

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Susanto, 2015

Bibliographic Reference	Susanto, Evan A.; Tong, Raymond K. Y.; Ockenfeld, Corinna; Ho, Newmen S. K.; Efficacy of robot-assisted fingers training in chronic stroke survivors: a pilot randomized-controlled trial; Journal of neuroengineering and rehabilitation; 2015; vol. 12 (no. 1); 1-9

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot-assisted group (N = 9)
Hand exoskeleton robot-assisted training for10 1 hour sessions. Duration 5 weeks.

Non-assisted group (N = 10)
20 1 hour sessions for 5 weeks.

Outcomes

Study timepoints

- Baseline
- 5 week (Post-intervention)
- 6 month (Post-intervention.)

Dichotomous outcome

Outcome	Robot-assisted group, Baseline, N = 9	Robot-assisted group, 5 week, N = 9	Robot-assisted group, 6 month, N = 9	Non-assisted group, Baseline, N = 10	Non-assisted group, 5 week, N = 10	Non-assisted group, 6 month, N = 10
Withdrawal for any reason 1 lost to follow-up in control group due to relocation No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 1 ; % = 10	n = 1 ; % = 10

Continuous outcome

Outcome	Robot-assisted group, Baseline, N = 9	Robot-assisted group, 5 week, N = 9	Robot-assisted group, 6 month, N = 9	Non-assisted group, Baseline, N = 10	Non-assisted group, 5 week, N = 10	Non-assisted group, 6 month, N = 10
Arm function (Fugl-Meyer assessment) Change scores. Scale rang 0-66. Mean (SD)	31.89 (11.98)	5.1 (6.6)	6.1 (10.9)	34.6 (8.16)	5.7 (4.4)	2.7 (4.4)

Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better

Also reports FMA-SE, FMA-WH, Wolf motor function test and ARAT.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted group-Non-assisted group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted group-Non-assisted group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted group-Non-assisted group-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcome-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot-assisted group-Non-assisted group-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Takahashi, 2016

Bibliographic Reference	Takahashi, Kayoko; Domen, Kazuhisa; Sakamoto, Tomosaburo; Toshima, Masahiko; Otaka, Yohei; Seto, Makiko; Irie, Katsumi; Haga, Bin; Takebayashi, Takashi; Hachisuka, Kenji; Efficacy of upper extremity robotic therapy in subacute poststroke hemiplegia: an exploratory randomized trial; Stroke; 2016; vol. 47 (no. 5); 1385-1388

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised Therapist supervised both groups from a distance.
Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot therapy (N = 30)
40 minutes of standard therapy plus robot therapy with ReoGo for 40 additional minutes, 7 times a week for 6 weeks.

Self-training (N = 30)
40 minutes of standard therapy plus therapist-directed self-training for 40 additional minutes, 7 times a week for 6 weeks.

Outcomes

Study timepoints

- Baseline
- 6 week (Post-intervention.)

Dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 30	Robot therapy, 6 week, N = 30	Self-training, Baseline, N = 30	Self-training, 6 week, N = 30
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0
Adverse events Deemed to be related to the study therapy. No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 30	Robot therapy, 6 week, N = 30	Self-training, Baseline, N = 30	Self-training, 6 week, N = 26
Activities of daily living (Functional Independence measure, physical items) Change scores. Scale range 13-91 Mean (SD)	61.1 (14.8)	12.6 (7.7)	62.2 (15.9)	15.1 (11)
Arm function (Fugl-Meyer assessment) Change scores. Scale range 0-66	29.1 (16.3)	9.5 (7.9)	31.8 (15.4)	6.9 (8.8)

Outcome	Robot therapy, Baseline, N = 30	Robot therapy, 6 week, N = 30	Self-training, Baseline, N = 30	Self-training, 6 week, N = 26
Mean (SD)				
Arm strength (Motricity Index) Change scores. Scale range ?0-100 Mean (SD)	55.73 (17.41)	6.5 (11)	54.54 (18.46)	8.4 (13.7)
Spasticity (MAS) Change scores. Scale 0-5 Mean (SD)	3.63 (2.25)	-0.1 (2.26)	3.71 (1.67)	-0.4 (1.66)

Activities of daily living (Functional Independence measure, physical items) - Polarity - Higher values are better
Arm function (Fugl-Meyer assessment) - Polarity - Higher values are better
Arm strength (Motricity Index) - Polarity - Higher values are better
Spasticity (MAS) - Polarity - Lower values are better
Also reports other functional outcomes: WMFT, FM proximal upper extremity, FM flexor synergy, Motor Activity Log, simple test for evaluating hand function and range of motion test.

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(FunctionalIndependencemeasure,physicalitems)-MeanSD-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(MAS)-MeanSD-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MotricityIndex)-MeanSD-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(Fugl-Meyerassessment)-MeanSD-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot therapy-Self-training-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Takebayashi, 2022

Bibliographic Reference	Takebayashi, T; Takahashi, K; Amano, S; Gosho, M; Sakai, M; Hashimoto, K; Hachisuka, K; Uchiyama, Y; Domen, K; Robot-Assisted Training as Self-Training for Upper-Limb Hemiplegia in Chronic Stroke: a Randomized Controlled Trial; Stroke; 2022; vol. 53 (no. 7); 2182-2191

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	No additional information.
Trial name / registration number	UMIN000022509.

Study type	Randomised controlled trial (RCT)
Study location	Japan.
Study setting	Outpatient follow up.
Study dates	November 29, 2016 to November 12, 2018.
Sources of funding	Funded by Teijin Pharma Limited.
Inclusion criteria	20-80 years old; upper-limb hemiplegia/hemiparesis due to a clinically first ever supratentorial stroke that occurred at least 6 months before the start of the study and were undergoing outpatient or ambulatory rehabilitation therapy to treat upper-limb dysfunction; Fugl-Meyer Assessment score <44; upper-limb distal function of 1b or above on the Stroke Impairment Assessment Set; a score no more than 2 on the Modified Ashworth Scale.
Exclusion criteria	Diagnosis with multiple strokes or cerebellar/brain stem strokes; extreme upper-limb pain; upper-limb function improvement without therapy; people with neuromuscular diseases; malignant tumours; balance or gait disturbances; other serious uncontrolled diseases, including cardiac, renal or hepatic diseases; peopel with serious aphasia or cognitive dysfunction (score of 24 points or less on the Mini-Mental State Examination); people with a history of robot-assisted upper-limb training or constraint induced movement training for upper-limb hemiplegia or who received a botulinum toxin injection within 16 weeks before enrollment; any person deemed ineligible by the investigator during the study.
Recruitment / selection of participants	People receiving outpatient rehabilitation at one of 25 hospitals or clinics throughout Japan.
Intervention(s)	Robot-assisted arm training N=87 Two groups combined. Group 1 (n=44) participated in 20 minutes of therapist-led occupational therapy and 40 minutes of robot self-training using the ReoGo-J device, group 2 (n=43) participated in 40 minutes of robot self-training using the ReoGo-J device then 20-minutes of therapist-led constraint induced movement therapy based on practice with the affected hand (shaping), task practice and behavioural practice of everyday functions with the affected hand. The ReoGo-J device mainly enabled movements of the shoulder, elbow and forearm and allowed for multiple tasks such as reaching, abduction and external rotation matched to the person's functional level. It could be set to a passive or active-assistive mode. The accuracy of performance could be assessed through visual feedback through a monitor available to the person participating in the therapy. In total 1 hour sessions of therapy were delivered 3 days a week for 10 weeks.

	Concomitant therapy: No additional information.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Unsupervised
Subgroup 8: Type of movement delivered by robotic device	Mixed
Population subgroups	No additional information.
Comparator	Any other intervention N=42 40 minutes of self-training, including sanding, placing, stretching and repetitive reaching, grasping and releasing practice to target the shoulder, elbow and forearm followed by 20 minutes of therapist-led occupational therapy. In total 1 hour sessions of therapy were delivered 3 days a week for 10 weeks.

	Concomitant therapy: No additional information.
Number of participants	129
Duration of follow-up	10 weeks (end of intervention)
Indirectness	No additional information.
Additional comments	Intention to treat and per-protocol analysis.

Study arms

Robot-assisted arm training (N = 87)
Two groups combined. Group 1 (n=44) participated in 20 minutes of therapist-led occupational therapy and 40 minutes of robot self-training using the ReoGo-J device, group 2 (n=43) participated in 40 minutes of robot self-training using the ReoGo-J device then 20-minutes of therapist-led constraint induced movement therapy based on practice with the affected hand (shaping), task practice and behavioural practice of everyday functions with the affected hand. The ReoGo-J device mainly enabled movements of the shoulder, elbow and forearm and allowed for multiple tasks such as reaching, abduction and external rotation matched to the person's functional level. It could be set to a passive or active-assistive mode. The accuracy of performance could be assessed through visual feedback through a monitor available to the person participating in the therapy. In total 1 hour sessions of therapy were delivered 3 days a week for 10 weeks. Concomitant therapy: No additional information.

Any other intervention (N = 42)
40 minutes of self-training, including sanding, placing, stretching and repetitive reaching, grasping and releasing practice to target the shoulder, elbow and forearm followed by 20 minutes of therapist-led occupational therapy. In total 1 hour sessions of therapy were delivered 3 days a week for 10 weeks. Concomitant therapy: No additional information.

Characteristics

Arm-level characteristics

Characteristic	Robot-assisted arm training (N = 87)	Any other intervention (N = 42)
% Female Sample size	n = 18 ; % = 21	n = 10 ; % = 27
Mean age (SD) (years) Mean (SD)	60 (12)	58 (10)
Ethnicity Sample size	n = NR ; % = NR	n = NR ; % = NR
Comorbidities Sample size	n = NR ; % = NR	n = NR ; % = NR
Severity Mean (SD)	NR (NR)	NR (NR)
Time after stroke (Months) Mean (SD)	37.7 (56.7)	34.3 (37.8)

Reports baseline characteristics for 84 people in the intervention arm, and 37 people in the control arm.

Outcomes

Study timepoints

- Baseline
- 10 week (End of intervention)

Continuous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 81	Robot-assisted arm training, 10 week, N = 81	Any other intervention, Baseline, N = 36	Any other intervention, 10 week, N = 36
Arm function (Fugl-Meyer assessment - upper extremity) Scale range: 0-66. Change scores. Using the full available set of data. Values for robot training groups combined. Robot training and usual care = 2.52 (0.59). Robot training and constraint training = 2.19 (0.61). Mean (SD)	26.2 (9.8)	2.36 (0.62)	25 (9)	1.49 (0.64)
Arm muscle strength (Motricity Index) Scale range: 0-99. Change scores. Using the full available set of data. Values for robot training groups combined. Robot training and usual care = 8.37 (1.79). Robot training and constraint training = 5.51 (1.87). Mean (SD)	NR (NR)	6.99 (2.32)	NR (NR)	5.28 (1.95)
Spasticity (modified Ashworth scale) Scale range: 0-4. Change scores. Using the full available set of data. Values for robot training groups combined. Robot training and usual care = -0.35 (0.63). Robot training and constraint training = -1.13 (0.66). Mean (SD)	NR (NR)	-0.73 (0.75)	NR (NR)	0.07 (0.69)
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) Scale range: 0-100. Change scores. Using the full available set of data.	NA (NA)	NA (NA)	NA (NA)	NA (NA)

Outcome	Robot-assisted arm training, Baseline, N = 81	Robot-assisted arm training, 10 week, N = 81	Any other intervention, Baseline, N = 36	Any other intervention, 10 week, N = 36
Mean (SD)				
SIS Strength Values for robot training groups combined. Robot training and usual care = 6.29 (1.89). Robot training and constraint training = 9.60 (1.99). Mean (SD)	NA (NA)	7.88 (2.55)	NA (NA)	4.43 (2.06)
SIS Memory Values for robot training groups combined. Robot training and usual care = 0.23 (1.52). Robot training and constraint training = 3.06 (1.59). Mean (SD)	NA (NA)	1.59 (2.1)	NA (NA)	1.4 (1.67)
SIS Emotion Values for robot training groups combined. Robot training and usual care = -0.71 (1.65). Robot training and constraint training = -0.20 (1.74). Mean (SD)	NA (NA)	-0.46 (1.71)	NA (NA)	0.78 (1.81)
SIS Communication Values for robot training groups combined. Robot training and usual care = 0.71 (1.45). Robot training and constraint training = 0.62 (1.53). Mean (SD)	NA (NA)	0.67 (1.49)	NA (NA)	0.99 (1.6)
SIS Activities of Daily Living Values for robot training groups combined. Robot training and	NA (NA)	3.52 (1.76)	NA (NA)	0.52 (1.76)

Outcome	Robot-assisted arm training, Baseline, N = 81	Robot-assisted arm training, 10 week, N = 81	Any other intervention, Baseline, N = 36	Any other intervention, 10 week, N = 36
usual care = 2.94 (1.61). Robot training and constraint training = 4.14 (1.69). Mean (SD)				
SIS Mobility Values for robot training groups combined. Robot training and usual care = 2.93 (1.70). Robot training and constraint training = 2.54 (1.79). Mean (SD)	NA (NA)	2.74 (1.76)	NA (NA)	0.5 (1.86)
SIS Hand Function Values for robot training groups combined. Robot training and usual care = 10.33 (2.43). Robot training and constraint training = 8.26 (2.55). Mean (SD)	NA (NA)	9.33 (2.7)	NA (NA)	3.06 (2.65)
SIS Social Participation Values for robot training groups combined. Robot training and usual care = 8.77 (2.98). Robot training and constraint training = 8.10 (3.13). Mean (SD)	NA (NA)	8.45 (3.07)	NA (NA)	1.37 (3.23)
SIS Stroke Recovery Values for robot training groups combined. Robot training and usual care = 8.33 (2.14). Robot training and constraint training = 8.77 (2.24). Mean (SD)	NA (NA)	8.54 (2.2)	NA (NA)	7.43 (2.35)

Outcome	Robot-assisted arm training, Baseline, N = 81	Robot-assisted arm training, 10 week, N = 81	Any other intervention, Baseline, N = 36	Any other intervention, 10 week, N = 36
SIS Physical Domain Values for robot training groups combined. Robot training and usual care = 5.50 (1.25). Robot training and constraint training = 6.13 (1.31). Mean (SD)	NA (NA)	5.8 (1.32)	NA (NA)	2.28 (1.36)

Arm function (Fugl-Meyer assessment - upper extremity) - Polarity - Higher values are better
Arm muscle strength (Motricity Index) - Polarity - Higher values are better
Spasticity (modified Ashworth scale) - Polarity - Lower values are better
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot-assisted arm training, Baseline, N = 87	Robot-assisted arm training, 10 week, N = 87	Any other intervention, Baseline, N = 42	Any other intervention, 10 week, N = 42
Withdrawal for any reason Robot therapy: 4 did not receive the intervention over 80%, 1 endpoint exceeded 1 week post intervention, 2 discontinued without efficacy data, 1 later turned out to be the same patient. Control: 1 later turned out to be the same patient. 2 withdrew consent. 1 did not receive the intervention, 1 discontinued without efficacy data, 1 did not receive the intervention over 80%. No of events	n = NA ; % = NA	n = 8 ; % = 9	n = NA ; % = NA	n = 6 ; % = 14
Adverse events - injuries and pain (back pain, pain in extremity, medical device site pain, fall, skin abrasion)	n = NA ; % = NA	n = 8 ; % = 9	n = NA ; % = NA	n = 0 ; % = 0

Outcome	Robot-assisted arm training, Baseline, N = 87	Robot-assisted arm training, 10 week, N = 87	Any other intervention, Baseline, N = 42	Any other intervention, 10 week, N = 42
Intervention: 4 back pain, 1 pain in extremity, 1 medical device site pain, 1 fall, 1 skin abrasion. Control: No events. No of events				

Withdrawal for any reason - Polarity - Lower values are better
Adverse events - injuries and pain (back pain, pain in extremity, medical device site pain, fall, skin abrasion) - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Fugl-Meyerassessment-upperextremity)-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(modifiedAshworthscale)-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISStrength-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISMemory-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISEmotion-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISCommunication-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISActivitiesofDailyLiving-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISMobility-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISHandFunction-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISSocialParticipation-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISStrokeRecovery-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatient-ReportedOutcomeMeasures(StrokeImpactScale)-SISPhysicalDomain-MeanSD-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-injuriesandpain(backpain,paininextremity,medicaldevicesitepain,fall,skinabrasion)-NoOfEvents-Robot-assisted arm training-Any other intervention-t10

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Taravati, 2021

Bibliographic Reference	Taravati, S.; Capaci, K.; Uzumcugil, H.; Tanigor, G.; Evaluation of an upper limb robotic rehabilitation program on motor functions, quality of life, cognition, and emotional status in patients with stroke: a randomized controlled study; Neurological Sciences; 2021; vol. 11; 11

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	NCT 04393480
Study location	Turkey

Study setting	rehabilitation hospital
Study dates	April 2016 - April 2019
Sources of funding	NR
Inclusion criteria	Single stroke. being an adult, duration of 4 to 30 months after stroke, a score of 16 or higher in mini mental state test, upper extremity Brunsstrom stage 2 or more, a fluent speaker in Turkish.
Exclusion criteria	Severe Apraxia, skin ulcers, multiple strokes, severe decompensated comorbidities, cardiac pacemakers, severe neuropsychological impairments, neglect syndrome, spasticity in the upper extremities greater than 3 on the MAS, severe joint contracted, a history of botulinum toxin injection in their upper extremity, and history of dose changes in drugs for spasticity in the last 3 months were excluded.
Recruitment / selection of participants	patients who were admitted to the Physical medicine and rehabilitation department of the institution between April 2016-April 2019 were included in the study if they fulfilled the inclusion criteria.
Intervention(s)	ReoGo-Motorika upper extremity rehabilitation system is a robotics-cased mobile rehabilitation system with a computerised touch screen. It is used to treat both active, passive and advanced functional patients with motor limitations. Continuous passive movement, active-assisted movement and active resistant movement are the most common movement types of the device. Robotic therapy is carried out under the supervision of a physiotherapist who controls the device. The patients in the study groups were instructed to use their arm and hand movements to reach virtual targets in the screen in front of them. The system helped then to levitate their affected arm against gravity. The study group had hand-arm robotic assisted therapy for 30-45 min, 5 days a week for 4 weeks. Concomitant therapy - conventional therapy was carried out by the same team of physiotherapists who were blinded to both groups. The control group received only conventional therapy for 5 days a week and 4 weeks, while the study groups received the same amount of conventional therapy in addition to rehabilitation with the robotic rehabilitation.
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	The control group received only conventional therapy carried out by a physiotherapist and consisted of ROM exercises, muscle strengthening, balance ad mobility training, exercises for improving activities of daily living, neurophysiological exercises, bed movements, sitting and transfer training, gait training, proprioceptive exercises, balance exercises, occupational therapy (60 mins daily), and cognitive rehabilitation b y an experienced psychologist given to those with cognitive impairment (45 min/twice week). Conventional physiotherapy was provided for 5 days a week and for 4 weeks.
Number of participants	45

Duration of follow-up	4 weeks end of intervention
Indirectness	NR
Additional comments	NR

Study arms

Robot therapy (N = 22)

conventional therapy (N = 23)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 45)**
Ethnicity Nominal	NR
Comorbidities Nominal	NR
Severity Nominal	NR

Arm-level characteristics

Characteristic	Robot therapy (N = 22)	conventional therapy (N = 23)
% Female Nominal	17.65	30
Mean age (SD) Mean (SD)	50.94 (17.2)	55.75 (11.61)
Time after stroke Mean (SD)	10.94 (8.02)	12.65 (8.42)

Outcomes

Study timepoints

- Baseline
- 4 week

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 22	Robot therapy, 4 week, N = 17	conventional therapy, Baseline, N = 23	conventional therapy, 4 week, N = 20
Activties of daily living (functional independence measure) 18-126, final value Mean (SD)	86.06 (26.2)	96.47 (23.55)	83.6 (23.7)	93.15 (21.99)

Outcome	Robot therapy, Baseline, N = 22	Robot therapy, 4 week, N = 17	conventional therapy, Baseline, N = 23	conventional therapy, 4 week, N = 20
Arm function (Fugl Meyer UE) 0-66, final value Mean (SD)	19 (10.46)	24.24 (10.02)	21.05 (10.85)	23.35 (10.01)
Arm strength (hand grip strength unclear measurement ?(N)) (Newtons) Mean (SD)	9.59 (9.49)	12.82 (12.41)	7.95 (9.25)	11 (12.98)
Stroke specific quality of life scale (SS-QOL) 49-245, final value Mean (SD)	118.65 (28.53)	138.59 (34.3)	133.75 (27.72)	140.8 (30.72)
Spastcity outcome - Modified ashworth scale total Mean (SD)	0.78 (0.84)	0.52 (0.7)	0.81 (0.83)	0.68 (0.78)

Activties of daily living (functional independence measure) - Polarity - Higher values are better
Arm function (Fugl Meyer UE) - Polarity - Higher values are better
Arm strength (hand grip strength unclear measurement ?(N)) - Polarity - Higher values are better
Stroke specific quality of life scale (SS-QOL) - Polarity - Higher values are better
Spastcity outcome - Modified ashworth scale total - Polarity - Lower values are better

Dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 22	Robot therapy, 4 week, N = 22	conventional therapy, Baseline, N = 23	conventional therapy, 4 week, N = 23
Withdrawal for any reason intervention reasons = 1 pneumonia, 2 general health disorder, 1 tumor reoccurrence, 1 withdrawn. Control reasons = 1 general health disorder, 2 withdrawn No of events	n = 0 ; % = 0	n = 5 ; % = 22.7	n = 0 ; % = 0	n = 3 ; % = 13

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activtiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention, measurement of outcome, and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention and missing data)*

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(handgripstrengthunclearmeasurement?(N))-MeanSD-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerUE)-MeanSD-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Strokespecificqualityoflifescale(SS-QOL)-MeanSD-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spastcityoutcome-Modifiedashworthscaletotal-MeanSD-Robot therapy-conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to effect of assignment to intervention and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Taveggia, 2016

Bibliographic Reference	Taveggia, Giovanni; Borboni, Alberto; Salvi, Lorena; Mulé, Chiara; Fogliaresi, Stefania; Villafañe, Jorge H.; Casale, Roberto; Efficacy of robot-assisted rehabilitation for the functional recovery of the upper limb in post-stroke patients: a randomized controlled study; European journal of physical and rehabilitation medicine; 2016; vol. 52 (no. 6); 767-773

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Mixed 0.5-12 months post-stroke.
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot therapy (N = 27)
Robot therapy with the Armeo Spring for 30 minutes per session, 5 times per week for 6 weeks.

Physical rehabilitation therapy (N = 27)
According to the Bobath concept for 30 minutes per session, 5 times a week for 6 weeks.

Outcomes

Study timepoints

- Baseline
- 6 week (Immediately post-intervention)
- 12 week (6 weeks post-intervention.)

Dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 27	Robot therapy, 6 week, N = 27	Robot therapy, 12 week, N = 27	Physical rehabilitation therapy, Baseline, N = 27	Physical rehabilitation therapy, 6 week, N = 27	Physical rehabilitation therapy, 12 week, N = 27
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 13 ; % = 52	n = NA ; % = NA	n = 0 ; % = 0	n = 14 ; % = 48
Adverse events Narrative statement No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 27	Robot therapy, 6 week, N = 27	Robot therapy, 12 week, N = 27	Physical rehabilitation therapy, Baseline, N = 27	Physical rehabilitation therapy, 6 week, N = 27	Physical rehabilitation therapy, 12 week, N = 27
Activities of daily living (functional	94.7 (22.1)	13.4 (20.9)	21.4 (17.9)	92.9 (20.7)	4.4 (21.2)	6.3 (20.4)

Outcome	Robot therapy, Baseline, N = 27	Robot therapy, 6 week, N = 27	Robot therapy, 12 week, N = 27	Physical rehabilitation therapy, Baseline, N = 27	Physical rehabilitation therapy, 6 week, N = 27	Physical rehabilitation therapy, 12 week, N = 27
independence measure) Scale range 0-126. Mean (SD)						
Arm muscle strength (Motricity Index) Change scores. Scale range 0-100 Mean (SD)	37 (19.3)	17.7 (20.8)	43.5 (21.7)	39.2 (15.6)	11.4 (16)	5.6 (16.1)
Spasticity (Ashworth MAS) Change scores. Scale range 0-5 Mean (SD)	5.6 (1.3)	-1.6 (1.5)	-1.6 (1.5)	5.4 (1.5)	-1 (1.6)	-1.4 (1.6)

1 Activities of daily living (functional independence measure) - Polarity - Higher values are better
2 Arm muscle strength (Motricity Index) - Polarity - Higher values are better
3 Spasticity (Ashworth MAS) - Polarity - Lower values are better

4

5

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Physical rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Adverseevents-NoOfEvents-Robot therapy-Physical rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy-Physical rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot therapy-Physical rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-Robot therapy-Physical rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(AshworthMAS)-MeanSD-Robot therapy-Physical rehabilitation therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot therapy-Physical rehabilitation therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Continuousoutcomes-Activitiesofdailyliving(functionalindependencemeasure)-MeanSD-Robot therapy-Physical rehabilitation therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Physical rehabilitation therapy-t12

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Partially applicable *(Follow up <6 months)*

Timmermans, 2014

Bibliographic Reference	Timmermans, Annick A. A.; Lemmens, Ryanne J. M.; Monfrance, Maurice; Geers, Richard P. J.; Bakx, Wilbert; Smeets, Rob J. E. M.; Seelen, Henk A. M.; Effects of task-oriented robot training on arm function, activity, and quality of life in chronic stroke patients: a randomized controlled trial; Journal of neuroengineering and rehabilitation; 2014; vol. 11 (no. 1); 1-12

Study details

Secondary publication of another included	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

study- see primary study for details	
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Lemmens RJM, Timmermans AAA, Janssen-Potten YJM, Pulles SANT, Geers RPJ, Bakx WGM, et al. Accelerometry measuring the outcome of robot-supported upper limb training in chronic stroke: a randomized controlled trial. *PLOS One* 2014;9(5):e96414.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Not stated/unclear

Subgroup 8: Type of movement delivered by robotic device	Mixed

Study arms

Robot-assisted training (N = 11)
With end-effector robot HapticMaster 4 times/ week, twice a day for 30 minutes (separated by 0.5 hour to 1 hour of rest).

Arm-hand training programme (N = 11)
4 times/ week, twice a day for 30 minutes (separated by 0.5 hour to 1 hour of rest).

Outcomes

Study timepoints
- Baseline
- 8 week (Post-intervention)
- 6 month (Post-intervention (6 months after the end of the intervention))

1 ***Dichotomous outcome***

Outcome	Robot-assisted training, Baseline, N = 11	Robot-assisted training, 8 week, N = 11	Robot-assisted training, 6 month, N = 11	Arm-hand training programme, Baseline, N = 11	Arm-hand training programme, 8 week, N = 11	Arm-hand training programme, 6 month, N = 11
Withdrawal for any reason No of events	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0	n = NA ; % = NA	n = 0 ; % = 0	n = 0 ; % = 0
Adverse events One patient in the experimental group fainted briefly once. No relationship with the intervention was found. No adverse effects of the study were found. No of events	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR	n = NA ; % = NA	n = 0 ; % = 0	n = NR ; % = NR

2 ***Continuous outcomes***

Outcome	Robot-assisted training, Baseline, N = 11	Robot-assisted training, 8 week, N = 11	Robot-assisted training, 6 month, N = 11	Arm-hand training programme, Baseline, N = 11	Arm-hand training programme, 8 week, N = 11	Arm-hand training programme, 6 month, N = 11
Person/ participant generic health-related quality if life (EQ-5D) VAS scale, range 0-100, change scores. Values as reported in Cochrane review.	65 (63 to 85)	80 (70 to 80)	74 (70 to 80)	70 (64 to 75)	78 (68 to 90)	75 (60 to 80)

Outcome	Robot-assisted training, Baseline, N = 11	Robot-assisted training, 8 week, N = 11	Robot-assisted training, 6 month, N = 11	Arm-hand training programme, Baseline, N = 11	Arm-hand training programme, 8 week, N = 11	Arm-hand training programme, 6 month, N = 11
Median (IQR)						
Arm function (FMMA) Change scores, scale 0-66. Values as reported in Cochrane review. Mean (SD)	NR (NR)	1.6 (10.8)	NR (NR)	NR (NR)	3.5 (32.7)	NR (NR)
Arm function (FMMA) Final values, scale 0-66. Median (IQR)	50 (39 to 58)	55 (46 to 56)	52 (43 to 59)	53 (47 to 57)	54 (51 to 59)	53 (50.7 to 59.5)

Person/ participant generic health-related quality if life (EQ-5D) - Polarity - Higher values are better
Arm function (FMMA) - Polarity - Higher values are better
Arm function (FMMA) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalforanyreason-NoOfEvents-Robot-assisted training-Arm-hand training programme-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Person/participantgenerichealth-relatedqualityiflife(EQ-5D)-MedianIQR-Robot-assisted training-Arm-hand training programme-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Person/participantgenerichealth-relatedqualityiflife(EQ-5D)-MedianIQR-Robot-assisted training-Arm-hand training programme-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMMA)-MeanSD-Robot-assisted training-Arm-hand training programme-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMMA)-MeanSD-Robot-assisted training-Arm-hand training programme-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMMA)-MedianIQR-Robot-assisted training-Arm-hand training programme-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMMA)-MedianIQR-Robot-assisted training-Arm-hand training programme-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Tomić, 2017

Bibliographic Reference	Tomić, Tijana J. Dimkić; Savić, Andrej M.; Vidaković, Aleksandra S.; Rodić, Sindi Z.; Isaković, Milica S.; Rodríguez-de-Pablo, Cristina; Keller, Thierry; Konstantinović, Ljubica M.; ArmAssist robotic system versus matched conventional therapy for poststroke upper limb rehabilitation: a randomized clinical trial; BioMed research international; 2017; vol. 2017

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Not stated/unclear
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot therapy (N = 13)
Additional robot therapy with the ArmAssist (AA) for 30 minutes administered over 15 sessions each lasting 30 minutes, scheduled 5 days per week (Monday to Friday) for 3 weeks

Additional occupational therapy (N = 13)
Additional occupational therapy for 30 minutes that was matched in its structure and amount to the AA training as close as possible and administered over 15 sessions each lasting 30 minutes, scheduled 5 days per week (Monday to Friday) for 3 weeks

Outcomes

Study timepoints
- Baseline
- 3 week (at the end of intervention)

Continuous and dichotomous outcomes

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 3 week, N = 13	Additional occupational therapy, Baseline, N = 13	Additional occupational therapy, 3 week, N = 13
Activites of daily living (Barthel Index) 0-100, change score Mean (SD)	65 (26.1)	21.2 (24.8)	65.4 (19.8)	13.1 (10.7)

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 3 week, N = 13	Additional occupational therapy, Baseline, N = 13	Additional occupational therapy, 3 week, N = 13
Arm function (Fugl meyer assessment- UE) 0-66, change score Mean (SD)	26.5 (7.7)	18 (9.4)	26.6 (7.5)	7.5 (5.5)
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0

Activites of daily living (Barthel Index) - Polarity - Higher values are better
Arm function (Fugl meyer assessment- UE) - Polarity - Higher values are better
Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

continuousoutcomes-acitivitesofdailyliving-barthelindex-MeanSD-Robot therapy-Additional occupational therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Armfunction(FuglmeyerassessmentUE)-MeanSD-Robot therapy-Additional occupational therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

continuousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Additional occupational therapy-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Valles, 2016

Bibliographic Reference	Valles, Karla Bustamante; Montes, Sandra; de Jesus Madrigal, Maria; Burciaga, Adan; Martínez, María Elena; Johnson, Michelle J.; Technology-assisted stroke rehabilitation in Mexico: a pilot randomized trial comparing traditional therapy to circuit training in a Robot/technology-assisted therapy gym; Journal of neuroengineering and rehabilitation; 2016; vol. 13 (no. 1); 1-15

Study details

Secondary publication of another included study- see primary study for details	No additional information.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear Mean 23 points FMA upper extremity.
Subgroup 2: Time after stroke at the start of the trial	Not stated/unclear Not described, but inclusion criteria says a minimum of 6 months post stroke.
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	Not stated/unclear
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed

1

Study arms

Robot therapy (N = 13)
24 2 hour therapy sessions over a 6-8 week period.

Standard rehabilitation therapy (N = 14)
24 2 hour therapy sessions over a 6-8 week period.

Outcomes

Study timepoints
- Baseline
- 8 week (Post-intervention)

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 10	Robot therapy, 8 week, N = 10	Standard rehabilitation therapy, Baseline, N = 10	Standard rehabilitation therapy, 8 week, N = 10
Arm function (Fugi-Meyer assessment) Scale range: 0-66. Change scores. Values reported in the Cochrane review used. Mean (SD)	23 (12.59)	4.6 (3.89)	22 (19.17)	5.1 (4.72)

Arm function (Fugi-Meyer assessment) - Polarity - Higher values are better
Also reports Rancho los Amigos functional test and Box and block test.

Dichotomous outcome

Outcome	Robot therapy, Baseline, N = 13	Robot therapy, 8 week, N = 13	Standard rehabilitation therapy, Baseline, N = 14	Standard rehabilitation therapy, 8 week, N = 14
Withdrawal for any reason Robot group: 3 (2 did not receive allocated intervention due to illness unrelated to the study, 1 discontinued intervention due to pathological depression). Traditional therapy group: 4 (1 did not receive the allocated intervention due to a lack of interest in the assigned therapy, 1 was lost to follow-up due to personal reasons, 2 discontined intervention due to illness and personal reasons). No of events	n = NA ; % = NA	n = 3 ; % = 23	n = NA ; % = NA	n = 4 ; % = 30

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousoutcome-Withdrawalduetoadverseevents-NoOfEvents-Robot therapy-Standard rehabilitation therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Function(FM),changescore-MeanSD-Robot therapy-Standard rehabilitation therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Vanoglio, 2017

Bibliographic Reference	Vanoglio, Fabio; Bernocchi, Palmira; Mulè, Chiara; Garofali, Francesca; Mora, Chiara; Taveggia, Giovanni; Scalvini, Simonetta; Luisa, Alberto; Feasibility and efficacy of a robotic device for hand rehabilitation in hemiplegic stroke patients: a randomized pilot controlled study; Clinical rehabilitation; 2017; vol. 31 (no. 3); 351-360

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)

Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Passive movement

Study arms

Robot therapy (N = 15)
Robot therapy with the Gloreha Professional (Idrogenet, Lumezzane, Italy) consisted of a total of 30 sessions, lasting 40 minutes per day, for 5 days per week

passive arm therapy (N = 15)
passive arm therapy for 30 sessions, lasting 40 minutes per day, for 5 days per week

Outcomes

Study timepoints

- Baseline
- 30 day (end of intervention)

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 15	Robot therapy, 30 day, N = 14	passive arm therapy, Baseline, N = 15	passive arm therapy, 30 day, N = 13
Arm function (Quick DASH) 19-95, change score Mean (SD)	59.7 (24.2)	15.7 (18.99)	65.6 (11.5)	0.43 (7.45)
Arm strength (Motricity Index) 0-100, change score Mean (SD)	37.4 (26.5)	23 (17.94)	28.1 (29.8)	5.2 (10.21)
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 1 ; % = 6.6	n = 0 ; % = 0	n = 2 ; % = 13.3

Arm function (Quick DASH) - Polarity - Lower values are better
Arm strength (Motricity Index) - Polarity - Higher values are better
Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-passive arm therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MotricityIndex)-MeanSD-Robot therapy-passive arm therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(QuickDASH)-MeanSD-Robot therapy-passive arm therapy-t30

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Villafañe, 2018

Bibliographic Reference Villafañe, Jorge H.; Taveggia, Giovanni; Galeri, Silvia; Bissolotti, Luciano; Mullè, Chiara; Imperio, Grace; Valdes, Kristin; Borboni, Alberto; Negrini, Stefano; Efficacy of short-term robot-assisted rehabilitation in patients with hand paralysis after stroke: a randomized clinical trial; Hand; 2018; vol. 13 (no. 1); 95-102

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Subgroup 1: Severity	Moderate (or NIHSS 5-14)
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Distal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement	Passive movement

delivered by robotic device	

Study arms

Robot therapy (N = 16)
Robot therapy with the hand Gloreha for 30 minutes for 3 days per week

Usual care (N = 16)
Physical and occupational arm therapy for 30 minutes 3 days per week

Outcomes

Study timepoints
- Baseline
- 3 week

Continuous outcomes

Outcome	Robot therapy, Baseline, N = 16	Robot therapy, 3 week, N = 16	Usual care, Baseline, N = 16	Usual care, 3 week, N = 16
Activties of daily living (Barthel Index) 0-100, change scores Mean (SD)	36.6 (21)	22.8 (2.4)	35.3 (23.6)	21.6 (2.4)

Outcome	Robot therapy, Baseline, N = 16	Robot therapy, 3 week, N = 16	Usual care, Baseline, N = 16	Usual care, 3 week, N = 16
Arm function (quickDASH) 0-100, change score Mean (SD)	68 (11)	9.9 (1.9)	61.2 (15.3)	9.1 (1.9)
Arm muscle strength (Motricity Index) 0-100, change scores Mean (SD)	30.6 (21.2)	24.4 (2.6)	36.3 (37.4)	14.9 (2.6)

Activties of daily living (Barthel Index) - Polarity - Higher values are better
Arm function (quickDASH) - Polarity - Higher values are better
Arm muscle strength (Motricity Index) - Polarity - Higher values are better

Dichotomous ouctomes

Outcome	Robot therapy, Baseline, N = 16	Robot therapy, 3 week, N = 16	Usual care, Baseline, N = 16	Usual care, 3 week, N = 16
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Dichotomousouctomes-Withdrawalforanyreason-NoOfEvents-Robot therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuosoutcomes-Armmusclestrength(MotricityIndex)-MeanSD-Robot therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuosoutcomes-Activtiesofdailyliving(BarthelIndex)-MeanSD-Robot therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuosoutcomes-Armfunction(quickDASH)-MeanSD-Robot therapy-Usual care-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High

Section	Question	Answer
Overall bias and Directness	Overall Directness	Directly applicable

Volpe, 2000

Bibliographic Reference	Volpe, B. T.; Krebs, H. I.; Hogan, N.; Edelstein, L.; Diels, C.; Aisen, M.; A novel approach to stroke rehabilitation: robot-aided sensorimotor stimulation; Neurology; 2000; vol. 54 (no. 10); 1938-1944

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Fasoli SE, Krebs HI, Ferraro M, Hogan N, Volpe BT. Does shorter rehabilitation limit potential recovery poststroke?. *Neurorehabilitation and Neural Repair* 2004;18:88-94.
Subgroup 1: Severity	Not stated/unclear

Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot assisted arm training (N = 30)
The treatment group used the MIT-Manus device for arm training for 1 hour per day, 5 days a week (for at least 25 sessions)

Placebo (N = 26)
The control group had similar initial exposure to the robot with the exception that half the tasks were performed with the unimpaired arm, and when the participant could not perform the task with the affected limb, the unimpaired limb was used to complete the task or the technician assisted the movement. The robot never actively moved the limbs of participants in the control group. Participants were exposed to the robot 1 hour per week

Outcomes

Study timepoints

- Baseline
- 5 week (post treatment)

Continuous outcomes

Outcome	Robot assisted arm training, Baseline, N = 30	Robot assisted arm training, 5 week, N = 30	Placebo, Baseline, N = 26	Placebo, 5 week, N = 26
Actvities of daily living (FIM - motor and cognition score) change score Mean (SD)	30.5 (4)	9.1 (3.3)	21.5 (5)	4.4 (2)
Arm function (FMA) 0-24, change score Mean (SD)	0 (0)	6 (3.5)	0 (0)	4 (1.7)
Arm strength (motor power score) change score, scale range unclear based on Cochrane information Mean (SD)	NR (NR)	4.1 (1.4)	NR (NR)	1.7 (1.7)

Actvities of daily living (FIM - motor and cognition score) - Polarity - Higher values are better
Arm function (FMA) - Polarity - Higher values are better
Arm strength (motor power score) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot assisted arm training, Baseline, N = 30	Robot assisted arm training, 5 week, N = 30	Placebo, Baseline, N = 26	Placebo, 5 week, N = 26
Withdrawal for any reason No of events	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0	n = 0 ; % = 0

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Actvitiesofdailyliving(Motricityindex-motor)-MeanSD-Robot assisted arm training-Placebo-t0

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to randomisation and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMwristhand)-MeanSD-Robot assisted arm training-Placebo-t0

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to randomisation and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(motorpowerscore)-MeanSD-Robot assisted arm training-Placebo-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to randomisation and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Robot assisted arm training-Placebo-t5

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(due to randomisation and missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Volpe, 2008

Bibliographic Reference	Volpe, Bruce T.; Lynch, Daniel; Rykman-Berland, Avrielle; Ferraro, Mark; Galgano, Michael; Hogan, Neville; Krebs, Hermano I.; Intensive sensorimotor arm training mediated by therapist or robot improves hemiparesis in patients with chronic stroke; Neurorehabilitation and neural repair; 2008; vol. 22 (no. 3); 305-310

Study details

Secondary publication of another included study- see primary study for details	No additional information.

Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Severe (or NIHSS 15-24) NIHSS 17 (SEM = 1)
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months) Mean 35-40 months
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Passive movement
Indirectness	Time period in trial 'at discharge'. The period is poorly defined and is not necessarily the end of intervention. Therefore, outcomes will be downgraded for indirectness.

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Study arms

Robot assisted arm training (N = 11)
Robotic training with the InMotion2 robot (the commercial version of MIT-Manus). All participants had an identical number of treatment sessions, and the sessions were of the same duration (1 hour per session, 3 times a week for 6 weeks).

Conventional therapy (N = 10)
Intensive movement protocol with a trained physiotherapist. All participants had an identical number of treatment sessions, and the sessions were of the same duration (1 hour per session, 3 times a week for 6 weeks).

Outcomes

Study timepoints

- Baseline
- 6 week (Time period in trial 'at discharge'. The period is poorly defined and is not necessarily the end of intervention. Therefore, outcomes will be downgraded for indirectness.)

Continuous outcomes

Outcome	Robot assisted arm training, Baseline, N = 11	Robot assisted arm training, 6 week, N = 11	Conventional therapy, Baseline, N = 10	Conventional therapy, 6 week, N = 10
Arm function (Fugl Meyer Assessment) Scale range: 0-66. Final values. Mean (SE)	NR (NR)	NR (NR)	NR (NR)	NR (NR)
Fugl Meyer Shoulder/elbow Scale range: 0-42. Final values.	12.79 (1.6)	15.73 (2)	11.43 (1)	15.1 (1.7)

Outcome	Robot assisted arm training, Baseline, N = 11	Robot assisted arm training, 6 week, N = 11	Conventional therapy, Baseline, N = 10	Conventional therapy, 6 week, N = 10
Mean (SE)				
Fugl Meyer Wrist/hand Scale range: 0-24. Final values. Mean (SE)	2.45 (1.3)	3.73 (2)	1.6 (0.8)	2.6 (0.9)
Spasticity (Ashworth scale) Scale range: Unclear. Final values. Mean (SE)	8.18 (1.4)	6.27 (1)	7.4 (1.5)	6 (1.3)
Stroke-specific Patient Reported Outcome Measures (Stroke Impact Scale) Scale range: 0-100. Final values. Mean (SE)	63.9 (3.1)	67.1 (2.4)	64.7 (2.3)	65.5 (2.4)

Arm function (Fugl Meyer Assessment) - Polarity - Higher values are better
Spasticity (Ashworth scale) - Polarity - Lower values are better
Stroke-specific Patient Reported Outcome Measures (Stroke Impact Scale) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-FuglMeyerShoulder/elbow-MeanSE-Robot assisted arm training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-FuglMeyerWrist/hand-MeanSE-Robot assisted arm training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Spasticity(Ashworthscale)-MeanSE-Robot assisted arm training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasures(StrokeImpactScale)-MeanSE-Robot assisted arm training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Wolf, 2015

Bibliographic Reference	Wolf, Steven L.; Sahu, Komal; Bay, R. Curtis; Buchanan, Sharon; Reiss, Aimee; Linder, Susan; Rosenfeldt, Anson; Alberts, Jay; The HAAPI (Home Arm Assistance Progression Initiative) trial: a novel robotics delivery approach in stroke rehabilitation; Neurorehabilitation and neural repair; 2015; vol. 29 (no. 10); 958-968

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.

	Linder SM, Rosenfeldt AB, Reiss A, Buchanan S, Sahu K, Bay CR, et al. The home stroke rehabilitation and monitoring system trial: a randomized controlled trial. *International Journal of Stroke* 2013;8(1):46-53.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Active assisted movement

Study arms

Robot assisted arm therapy (N = 51)

Robot therapy with the Hand Mentor Pro (Kinetic Muscles Incs) for 60 minutes over a 8 (to 12) weeks period

Conventional therapy (N = 48)
Home exercises for the arm therapy for 60 minutes over a 8 (to 12) weeks period

Outcomes

Study timepoints
- Baseline
- 8 week (8-12 weeks. End of intervention.)

Continuous outcomes

Outcome	Robot assisted arm therapy, Baseline, N = 51	Robot assisted arm therapy, 8 week, N = 47	Conventional therapy, Baseline, N = 48	Conventional therapy, 8 week, N = 45
Arm function (Fugl Meyer Assessment) Scale range: 0-66. Final values. Reported proximal and distal subscales, total scale used. Mean (95% CI)	34.1 (24.2 to 44)	43.4 (30.8 to 56)	33.3 (23.6 to 43)	42.9 (30.4 to 55.3)

Arm function (Fugl Meyer Assessment) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Robot assisted arm therapy, Baseline, N = 51	Robot assisted arm therapy, 8 week, N = 51	Conventional therapy, Baseline, N = 48	Conventional therapy, 8 week, N = 48
Discontinuation for any reason Robot: 2 no show for end of trial, 1 noncompliant, 1	n = NA ; % = NA	n = 4 ; % = 7.8	n = NA ; % = NA	n = 3 ; % = 6.3

Outcome	Robot assisted arm therapy, Baseline, N = 51	Robot assisted arm therapy, 8 week, N = 51	Conventional therapy, Baseline, N = 48	Conventional therapy, 8 week, N = 48
withdrew. Control: 1 recurrent stroke, 1 got insurance approval for traditional therapy, 1 no show for end of trial. No of events				

Discontinuation for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-MeanNineFivePercentCI-Robot assisted arm therapy-Conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Discontinuationforanyreason-NoOfEvents-Robot assisted arm therapy-Conventional therapy-t8

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns
Overall bias and Directness	Overall Directness	Directly applicable

Wu et al.

Bibliographic Reference	Wu, Ching-yi; Chen, Ming-De; Chen, Yu-ting; Wu, Li-Ling; Lin, Keh-chung; Unilateral and Bilateral Robot-Assisted Arm Training Had Differential Effects on Upper Limb Function in Chronic Stroke Survivors; vol. 26; 362-363

Study details

Secondary publication of another included study- see primary study for details	Wu, Ching-yi; Yang, Chieh-ling; Chuang, Li-ling; Lin, Keh-chung; Chen, Hsieh-ching; Chen, Ming-de; Huang, Wan-chien; Effect of therapist-based versus robot-assisted bilateral arm training on motor control, functional performance, and quality of life after chronic stroke: a clinical trial; 2012; vol. 92; 1006-1016
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Wu, Ching-yi; Chuang, Li-ling; Chen, Ming-De; Chen, Yu-ting; Lin, Keh-chung; Abstract P289: Therapist-Based and Robot-Assisted Physical Training Have Differential Effects on Motor Control of Upper Limb and Quality of Life after Chronic Stroke; 2012

Wu, 2012

Bibliographic Reference	Wu, Ching-yi; Chuang, Li-ling; Chen, Ming-De; Chen, Yu-ting; Lin, Keh-chung; Abstract P289: Therapist-Based and Robot-Assisted Physical Training Have Differential Effects on Motor Control of Upper Limb and Quality of Life after Chronic Stroke; 2012

Study details

Secondary publication of another included study- see primary study for details	Wu, Ching-yi; Yang, Chieh-ling; Chuang, Li-ling; Lin, Keh-chung; Chen, Hsieh-ching; Chen, Ming-de; Huang, Wan-chien; Effect of therapist-based versus robot-assisted bilateral arm training on motor control, functional performance, and quality of life after chronic stroke: a clinical trial; 2012; vol. 92; 1006-1016
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Wu, Ching-yi; Chen, Ming-De; Chen, Yu-ting; Wu, Li-Ling; Lin, Keh-chung; Unilateral and Bilateral Robot-Assisted Arm Training Had Differential Effects on Upper Limb Function in Chronic Stroke Survivors; vol. 26; 362-363

Wu, 2012

Bibliographic Reference	Wu, Ching-yi; Yang, Chieh-ling; Chuang, Li-ling; Lin, Keh-chung; Chen, Hsieh-ching; Chen, Ming-de; Huang, Wan-chien; Effect of therapist-based versus robot-assisted bilateral arm training on motor control, functional performance, and quality of life after chronic stroke: a clinical trial; 2012; vol. 92; 1006-1016

1 **Study details**

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review. Wu, Ching-yi; Chuang, Li-ling; Chen, Ming-De; Chen, Yu-ting; Lin, Keh-chung; Abstract P289: Therapist-Based and Robot-Assisted Physical Training Have Differential Effects on Motor Control of Upper Limb and Quality of Life after Chronic Stroke; 2012 Wu, Ching-yi; Chen, Ming-De; Chen, Yu-ting; Wu, Li-Ling; Lin, Keh-chung; Unilateral and Bilateral Robot-Assisted Arm Training Had Differential Effects on Upper Limb Function in Chronic Stroke Survivors; vol. 26; 362-363
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months)
Subgroup 3: Region of upper limb trained	Mixed

Subgroup 4: Dose (hours per day)	≥1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Mixed Has three modes: a passive-passive mode, active-passive mode and active-active mode.

Study arms

Robot assisted arm training (N = 14)
Robot-assisted (Bi-Manu-Track) arm trainer (RAT Group). Each group received treatment for 90 to 105 minutes per session, 5 sessions on weekdays, for 4 weeks.

Conventional therapy (N = 28)
A combination of two arms. 1) therapist-mediated bilateral arm training group (n=14), 2) CT involved weight bearing, stretching, strengthening of the paretic arms, coordination, unilateral and bilateral fine-motor tasks, balance, and compensatory practice on functional tasks. Each group received treatment for 90 to 105 minutes per session, 5 sessions on weekdays, for 4 weeks.

Outcomes

Study timepoints
- Baseline

- 4 week (End of intervention)

Continuous outcomes

Outcome	Robot assisted arm training, Baseline, N = 14	Robot assisted arm training, 4 week, N = 14	Conventional therapy, Baseline, N = 28	Conventional therapy, 4 week, N = 28
Arm function (Fugl Meyer Assessment) Reports subscales for proximal and distal. Total values used. Scale range: 0-66. Final values. Values for the therapist-based arm training and control treatment arms were combined. Mean (SD)	43.29 (10.09)	47.14 (10.97)	44.43 (11.08)	48.64 (11.4)
Stroke-specific Patient Reported Outcome Measures (Stroke Impact Scale) Total score used, subscales also reported. Scale range: 0-100. Final values. Values for the therapist-based arm training and control treatment arms were combined. Mean (SD)	68.62 (7.62)	73.97 (8.68)	64.75 (8.76)	66.18 (10.11)

Arm function (Fugl Meyer Assessment) - Polarity - Higher values are better
Stroke-specific Patient Reported Outcome Measures (Stroke Impact Scale) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(FuglMeyerAssessment)-MeanSD-Robot assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Stroke-specificPatientReportedOutcomeMeasures(StrokeImpactScale)-MeanSD-Robot assisted arm training-Conventional therapy-t4

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Low
Overall bias and Directness	Overall Directness	Directly applicable

Xu, 2020

Bibliographic Reference	Xu, Q.; Li, C.; Pan, Y.; Li, W.; Jia, T.; Li, Z.; Ma, D.; Pang, X.; Ji, L.; Impact of smart force feedback rehabilitation robot training on upper limb motor function in the subacute stage of stroke; Neurorehabilitation; 2020; vol. 47 (no. 2); 209-215

Study details

Secondary publication of another included	NR

study- see primary study for details	
Other publications associated with this study included in review	NR
Trial name / registration number	NR
Study type	Randomised controlled trial (RCT)
Study location	China
Study setting	Rehabilitation hospital
Study dates	NR
Sources of funding	The study was supported by the Beijing Muncipicipal Administration of hospitals youth programme (No. QML2019002).
Inclusion criteria	First onset of Cerebral infarction or cerebral haemorrhage; patients with the course of disease between 1 and 6 months; patients aged between 18 and 75 years; patients who can coordinate the rehabilitation treatment; patients who signed the informed consent form.
Exclusion criteria	Patients with recurrent stroke; patients with severe cardiac insufficiency or renal insufficiency; patients with aphasia; patients with cognitive impairment; patients with psychiatric symptoms; patients with pacemakers; patients carrying internal metal fixation at the electrical stimulation site; patients with severe spasticity caused by dystonia; patients with severe osteoarthritis or severe osteoporosis.
Recruitment / selection of participants	NR
Intervention(s)	The robot (model Fourier M2, Fourier Intelligence, Shanghai, China) was used to perform a variety of intensive functional training n the affected side of each patient through various real-life mechanical scene simulations and comprehensive training methods. the treatment was guided by a therapist. Each patient was required to use the affected sides upper limbs, shoulder joints, and elbow joints to move the handle to the targets on the affected side in accordance with the designated order for motion control training. Robot training was provided in addition 20 min/time, once/day and five days/week.

	Concomitant therapy - the patients in both groups received regular neurological medical and physical therapy with equal treatment volume. A 6 weeks rehabilitation programme was designed for all the patients.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Proximal limb
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised
Subgroup 8: Type of movement delivered by robotic device	Not stated/unclear
Population subgroups	NR
Comparator	Each patient underwent traditional occupational therapy targeting the scapula and joints of the uppers limbs of the affected side, such as therapist -assisted stretch, loosening, or patients-based designed activities, such as roller training, pushing level sanding board, looping, stick insertion, or item transferring. Control group was trained with traditional exercises, 40 min, once/day, and five days/week.

Number of participants	55
Duration of follow-up	6 weeks post treatment
Indirectness	NR
Additional comments	NR

Study arms

Rehabilitation robot training (N = 22)

Conventional therapy (N = 23)

Characteristics

Arm-level characteristics

Characteristic	Rehabilitation robot training (N = 22)	Conventional therapy (N = 23)
% Female Nominal	25	30
Mean age (SD) Mean (SD)	62.2 (10.1)	60.7 (10.6)
Ethnicity	NR	NR

Characteristic	Rehabilitation robot training (N = 22)	Conventional therapy (N = 23)
Nominal		
Comorbidities Nominal	NR	NR
Severity Nominal	NR	NR
Time after stroke (days) Mean (SD)	51 (19.1)	47.2 (24)

Outcomes

Study timepoints

- Baseline
- 6 week

Continuous outcomes

Outcome	Rehabilitation robot training, Baseline, N = 22	Rehabilitation robot training, 6 week, N = 20	Conventional therapy, Baseline, N = 23	Conventional therapy, 6 week, N = 20
Activties of daily living (Modified Barthel index) 0-100, final value Mean (SD)	47.8 (17)	54.8 (20.2)	47.3 (15)	53.3 (16.2)

Outcome	Rehabilitation robot training, Baseline, N = 22	Rehabilitation robot training, 6 week, N = 20	Conventional therapy, Baseline, N = 23	Conventional therapy, 6 week, N = 20
Arm function (FMA total) 0-100, final value Mean (SD)	25.1 (8.6)	31.8 (10)	30.4 (8.8)	35.4 (9.1)

Activties of daily living (Modified Barthel index) - Polarity - Higher values are better

Arm function (FMA total) - Polarity - Higher values are better

Dichotomous outcomes

Outcome	Rehabilitation robot training, Baseline, N = 22	Rehabilitation robot training, 6 week, N = 22	Conventional therapy, Baseline, N = 23	Conventional therapy, 6 week, N = 23
Withdrawal for any reason intervention reasons = 1 change of disease condition, 1 discharged halfway. control reasons = 2 changes to disease conditions and 1 discharged halfway No of events	n = 0 ; % = 0	n = 2 ; % = 9	n = 0 ; % = 0	n = 3 ; % = 13

Withdrawal for any reason - Polarity - Lower values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activtiesofdailyliving(ModifiedBarthelindex)-MeanSD-rehabilitation robot training-conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(Due to bias arising from the randomisation process)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armfunction(FMAtotal)-MeanSD-Rehabilitation robot training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(Due to bias arising from the randomisation process)*
Overall bias and Directness	Overall Directness	Directly applicable

Dichotomousoutcomes-Withdrawalforanyreason-NoOfEvents-Rehabilitation robot training-Conventional therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	Some concerns *(Due to bias arising from the randomisation process)*
Overall bias and Directness	Overall Directness	Directly applicable

Yoo, 2013

Bibliographic Reference	Yoo, Doo Han; Cha, Yong Jun; kyoung Kim, Su; Lee, Jae Shin; Effect of three-dimensional robot-assisted therapy on upper limb function of patients with stroke; Journal of Physical Therapy Science; 2013; vol. 25 (no. 4); 407-409

Study details

Secondary publication of another included study- see primary study for details	No additional information.
Other publications associated with this study included in review	This study was included in the Cochrane review that this review was based on: Mehrholz J, Pohl M, Platz T, Kugler J, Elsner B. Electromechanical and robot-assisted arm training for improving activities of daily living, arm function, and arm muscle strength after stroke. Cochrane Database of Systematic Reviews 2018, Issue 9. Art. No.: CD006876. DOI: 10.1002/14651858.CD006876.pub5. For further information about the data extraction please see the Cochrane review.
Study type	Randomised controlled trial (RCT)
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Chronic (>6 months) Mean 41.5-45.8 months
Subgroup 3: Region of upper limb trained	Not stated/unclear
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	<5 days per week
Subgroup 6: Dose (duration)	≥6 weeks
Subgroup 7: Level of supervision	Supervised

Subgroup 8: Type of movement delivered by robotic device	Mixed Device can deliver passive or active assisted movement

Study arms

Robot assisted arm training (N = 11)
3-dimensional robot-assisted therapy (RAT) and conventional rehabilitation therapy (CT) for a total of 90 minutes (RAT: 30 minutes, CT: 60 minutes) a day with 10 minutes rest halfway through the session, received training 3 days a week for 6 weeks

Conventional rehabilitation therapy (N = 11)
The control group received only CT for 60 minutes a day on the same days as the first group

Outcomes

Study timepoints
- Baseline
- 6 week (End of intervention)

Continuous outcomes

Outcome	Robot assisted arm training, Baseline, N = 11	Robot assisted arm training, 6 week, N = 11	Conventional rehabilitation therapy, Baseline, N = 11	Conventional rehabilitation therapy, 6 week, N = 11
Activities of daily living (Modified Barthel Index) Scale range: 0-100. Final values. Mean (SD)	77.5 (9.6)	77.9 (9.7)	75.3 (5)	75.4 (5.1)
Arm function (Wolf Motor Function Test) Scale range: 0-85 (assumed by number of items in the scale). Final values. Mean (SD)	41.7 (15.5)	43.4 (15.9)	33 (6.1)	33.3 (6.3)
Arm muscle strength (grip power) (kg) Final values. Mean (SD)	7.5 (5.6)	8.5 (5.8)	5 (2.4)	5.1 (2.3)

Activities of daily living (Modified Barthel Index) - Polarity - Higher values are better
Arm function (Wolf Motor Function Test) - Polarity - Higher values are better
Arm muscle strength (grip power) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Activitiesofdailyliving(ModifiedBarthelIndex)-MeanSD-Robot assisted arm training-Conventional rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Physicalfunction-upperlimb(WolfMotorFunctionTest)-MeanSD-Robot assisted arm training-Conventional rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armmusclestrength(grippower)-MeanSD-Robot assisted arm training-Conventional rehabilitation therapy-t6

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High
Overall bias and Directness	Overall Directness	Directly applicable

Zengin-Metli, 2018

Bibliographic Reference	Zengin-Metli, D.; Ozbudak-Demir, S.; Eraktas, I.; Binay-Safer, V.; Ekiz, T.; Effects of robot assistive upper extremity rehabilitation on motor and cognitive recovery, the quality of life, and activities of daily living in stroke patients; Journal of Back & Musculoskeletal Rehabilitation; 2018; vol. 31 (no. 6); 1059-1064

Study details

Secondary publication of another included study- see primary study for details	NR
Other publications associated with this study included in review	NR
Trial name / registration number	NR
Study location	Turkey
Study setting	Stroke rehabilitation centre
Study dates	NR
Sources of funding	NR
Inclusion criteria	Stroke patients according to the WHO, age between 45-75 years, time after stroke was 6-24 weeks, upper extremity Brunnstrom stage 3-6, cooperative
Exclusion criteria	unstable patients with systematic problems such as heart or lung disease, limited range of motion of the upper limb, ataxia. dystonia and dyskinesia, visual and or haring impairment, aphasia, severe spasticity (Ashworth 3-4), received Botulinum toxin A injection in the last 6 months, shoulder subluxation or severe pain in the upper limbs.

Recruitment / selection of participants	NR
Intervention(s)	Armeo Spring HocomAG Inc. was used for robotic rehabilitation. Assistive component of the robot was set as tailor as to the subjects clinical status. the programme was individualised according to the patients ability and motor stage and level of difficulty was progressed or regressed during the rehabilitation process through the therapists control. The computer game encouraged shoulder adduction-abduction and flexion and extension along with wrist and hand movements by the joystick gripping. concomitant therapy - Conventional program consisted of neurophysiological exercises with Brunnstron approach, range of motion exercises and postural education.
Subgroup 1: Severity	Not stated/unclear
Subgroup 2: Time after stroke at the start of the trial	Subacute (7 days - 6 months)
Subgroup 3: Region of upper limb trained	Mixed
Subgroup 4: Dose (hours per day)	<1 hour
Subgroup 5: Dose (days per week)	≥5 days per week
Subgroup 6: Dose (duration)	<6 weeks
Subgroup 7: Level of supervision	Supervised

Subgroup 8: Type of movement delivered by robotic device	Active assisted movement
Population subgroups	NR
Comparator	Conventional program consisted of neurophysiological exercises with Brunnstron approach, range of motion exercises and postural education.
Duration of follow-up	post treatment (3 weeks intervention)
Indirectness	NR

Study arms

Robotic rehabilitation (Armeo Spring) (N = 20)

conventional rehabilitation (N = 15)

Characteristics

Study-level characteristics

Characteristic	**Study (N = 35)**
Ethnicity Nominal	NR

Characteristic	Study (N = 35)
Comorbidities Nominal	NR
Severity Nominal	NR

Arm-level characteristics

Characteristic	Robotic rehabilitation (Armeo Spring) (N = 20)	conventional rehabilitation (N = 15)
% Female Nominal	25	60
Mean age (SD) Nominal	NR	NR
Mean age (SD) Mean (SD)	59.25 (8.1)	63.27 (3.88)
Time after stroke weeks Mean (SD)	10.7 (4.9)	11.33 (5.26)

Outcomes

Study timepoints

- Baseline
- 3 week (post intervention)

Continuous outcomes

Outcome	Robotic rehabilitation (Armeo Spring), Baseline, N = 20	Robotic rehabilitation (Armeo Spring), 3 week, N = 20	conventional rehabilitation, Baseline, N = 15	conventional rehabilitation, 3 week, N = 15
Arm function (FMA shoulder/elbow/forearm) change score Mean (SD)	20.3 (18)	4.35 (3.2)	24.07 (4.73)	1.4 (1.88)
Person/participant generic health related quality of life (SF-36 PCS) 0-100 Mean (SD)	30.21 (7.38)	4.36 (6.29)	33.19 (8.52)	1.37 (5.22)
Person/participant generic health related quality of life (SF-36 MCS) 0-100, change score Mean (SD)	50 (10.73)	2.5 (7.86)	38.9 (15.22)	3.21 (5.37)
Activties of daily living (FIM) 0-126 Mean (SD)	92.6 (18.42)	14.7 (8.47)	91.47 (16.95)	13.67 (11.52)

Outcome	Robotic rehabilitation (Armeo Spring), Baseline, N = 20	Robotic rehabilitation (Armeo Spring), 3 week, N = 20	conventional rehabilitation, Baseline, N = 15	conventional rehabilitation, 3 week, N = 15
Arm strength (MI) change score Mean (SD)	NR (NR)	21.5 (3.87)	NR (NR)	22.87 (5)

Arm function (FMA shoulder/elbow/forearm) - Polarity - Higher values are better
Person/participant generic health related quality of life (SF-36 PCS) - Polarity - Higher values are better
Person/participant generic health related quality of life (SF-36 MCS) - Polarity - Higher values are better
Activties of daily living (FIM) - Polarity - Higher values are better
Arm strength (MI) - Polarity - Higher values are better

Critical appraisal - Cochrane Risk of Bias tool (RoB 2.0) Normal RCT

Continuousoutcomes-Armfunction(Functionalindependencemeasure-motor)-MeanSD-Robotic rehabilitation (Armeo Spring)-conventional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(no details on randomisation or missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36PCS)-MeanSD-Robotic rehabilitation (Armeo Spring)-conventional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(no details on randomisation or missing data and bias in measurement of the outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Person/participantgenerichealthrelatedqualityoflife(SF-36MCS)-MeanSD-Robotic rehabilitation (Armeo Spring)-conventional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(no details on randomisation or missing data and bias in measurement of the outcome)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Activtiesofdailyliving(FIM)-MeanSD-Robotic rehabilitation (Armeo Spring)-conventional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(no details on randomisation or missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Continuousoutcomes-Armstrength(MI)-MeanSD-Robotic rehabilitation (Armeo Spring)-conventional rehabilitation-t3

Section	Question	Answer
Overall bias and Directness	Risk of bias judgement	High *(no details on randomisation or missing data)*
Overall bias and Directness	Overall Directness	Directly applicable

Appendix E – Forest plots

Figure 1: Person/participant health related quality of life (SF-36 PCS, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Aprile 2020	1.66	5.665922	89	1.37	5.866235	91	83.7%	0.29 [-1.39, 1.97]
Zengin-Metli 2018	4.36	6.29	20	1.37	5.22	15	16.3%	2.99 [-0.83, 6.81]
Total (95% CI)			**109**			**106**	**100.0%**	**0.73 [-0.81, 2.27]**

Heterogeneity: Chi² = 1.61, df = 1 (P = 0.20); I² = 38%
Test for overall effect: Z = 0.93 (P = 0.35)

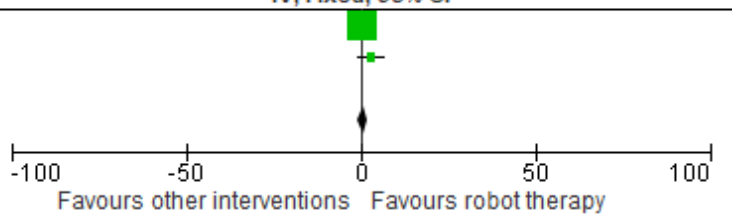


Figure 2: Person/participant health related quality of life (SF-36 MCS, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Aprile 2020	3.15	9.435318	89	4.46	9.72692	91	71.1%	-1.31 [-4.11, 1.49]
Zengin-Metli 2018	2.5	7.86	20	3.21	5.37	15	28.9%	-0.71 [-5.10, 3.68]
Total (95% CI)			**109**			**106**	**100.0%**	**-1.14 [-3.50, 1.22]**

Heterogeneity: Chi² = 0.05, df = 1 (P = 0.82); I² = 0%
Test for overall effect: Z = 0.94 (P = 0.35)

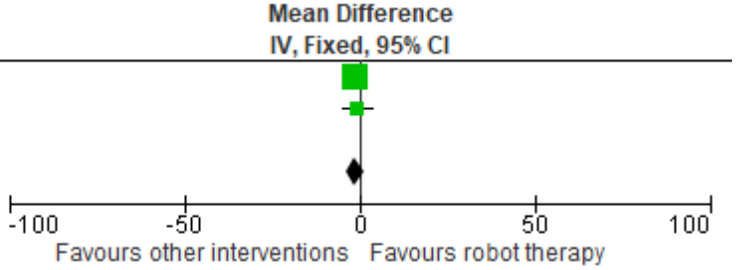


Figure 3: Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final values and change scores) at end of intervention

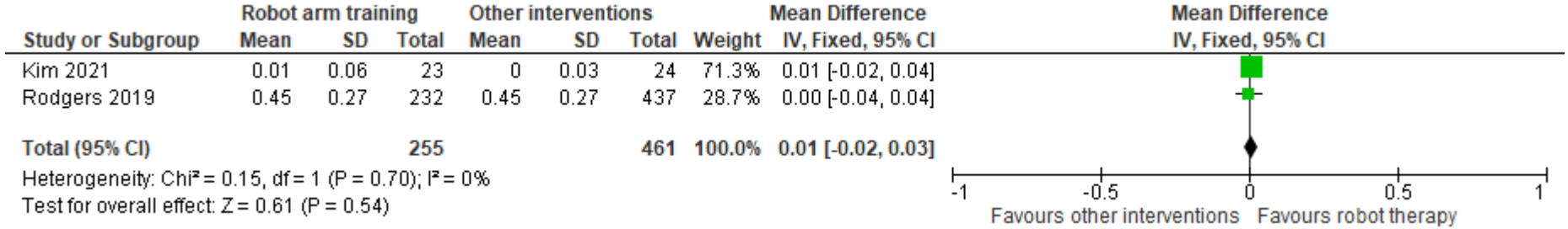


Figure 4: Person/participant health related quality of life (EQ5D, 0-100, higher values are better, change score) at ≥6 months

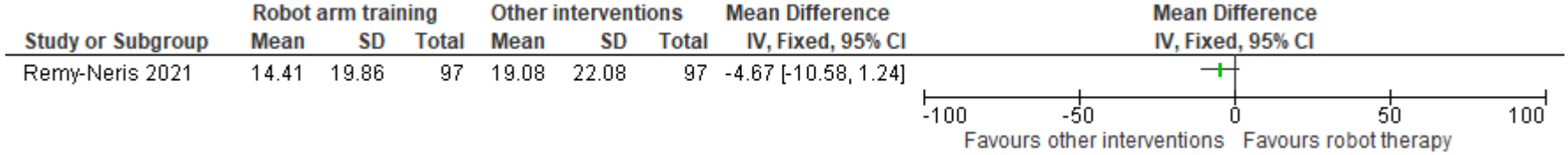


Figure 5: Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final values) at ≥6 months

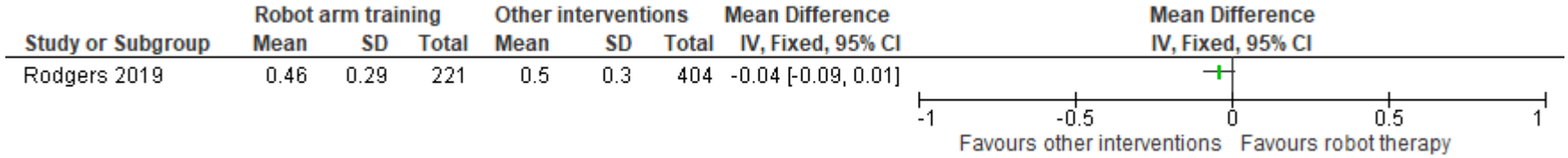


Figure 6: Activities of daily living (Barthel index, functional independence measure, stroke impact scale, MAL, Frenchay arm test, ABILHAND [different scale ranges], higher values are better, change scores) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Aprile 2020	23.87	18.51051	91	22.98	18.52627	99	5.3%	0.05 [-0.24, 0.33]
Bishop 2014	-0.36	12.3	14	6.78	19.1	14	3.8%	-0.43 [-1.18, 0.32]
Burgar 2011	19.6	8.52	36	15.9	6.363961	18	4.4%	0.46 [-0.11, 1.04]
Carpinella 2020	9.3	5.8	19	8.7	11.6	19	4.2%	0.06 [-0.57, 0.70]
Chen 2021A	28.9	14.26	10	21	8.89	10	3.3%	0.64 [-0.27, 1.54]
Chinembiri 2021	40	9.9	20	10.2	3.9	25	2.9%	4.07 [3.01, 5.13]
Fazekas 2007	12.07	9.26	15	25.53	14.32	15	3.7%	-1.09 [-1.86, -0.31]
Hesse 2014	25.2	11	25	16	15.7	25	4.4%	0.67 [0.10, 1.24]
Housman 2009	0.2	0.4	17	0.1	0.3	17	4.1%	0.28 [-0.40, 0.95]
Iwamoto 2019	9.17	5.97	6	2.5	4.52	5	2.3%	1.13 [-0.19, 2.46]
Lee 2016	10	7.1	22	9.6	6.5	22	4.4%	0.06 [-0.53, 0.65]
Lee 2018	5.8	5.73	15	3.33	4.95	15	3.9%	0.45 [-0.28, 1.17]
Liao 2012	0.3	0.2	10	0	0.3	10	3.2%	1.13 [0.17, 2.09]
Lin 2022	10.81	9.98	72	9.99	10.72	72	5.2%	0.08 [-0.25, 0.41]
Lum 2002	1.2	4.326662	13	0	0.001	14	3.8%	0.39 [-0.37, 1.15]
Lum 2006	2.9	1.2	24	3.2	1.4	6	3.3%	-0.24 [-1.13, 0.66]
Masiero 2007	32.6	7.2	17	25.5	10.5	18	4.0%	0.77 [0.08, 1.46]
Masiero 2011	1.8	1.4	11	1	0.7	10	3.4%	0.68 [-0.20, 1.57]
Remy-Neris 2021	10.81	9.38	105	10.68	10.02	103	5.3%	0.01 [-0.26, 0.29]
Takahashi 2016	12.6	7.7	30	15.1	11	26	4.6%	-0.26 [-0.79, 0.26]
Taveggia 2016	13.4	20.9	27	4.4	21.2	27	4.5%	0.42 [-0.12, 0.96]
Tomic 2017	21.2	24.8	13	13.1	10.7	13	3.7%	0.41 [-0.37, 1.19]
Villafane 2017	22.8	2.4	16	21.6	2.4	16	4.0%	0.49 [-0.22, 1.19]
Volpe 2000	9.1	3.3	30	4.4	2	26	4.3%	1.67 [1.05, 2.29]
Zengin-Metli 2018	14.7	8.47	20	13.67	11.52	15	4.1%	0.10 [-0.57, 0.77]
Total (95% CI)			**678**			**640**	**100.0%**	**0.41 [0.16, 0.67]**

Heterogeneity: Tau² = 0.30; Chi² = 109.35, df = 24 (P < 0.00001); I² = 78%

Test for overall effect: Z = 3.14 (P = 0.002)

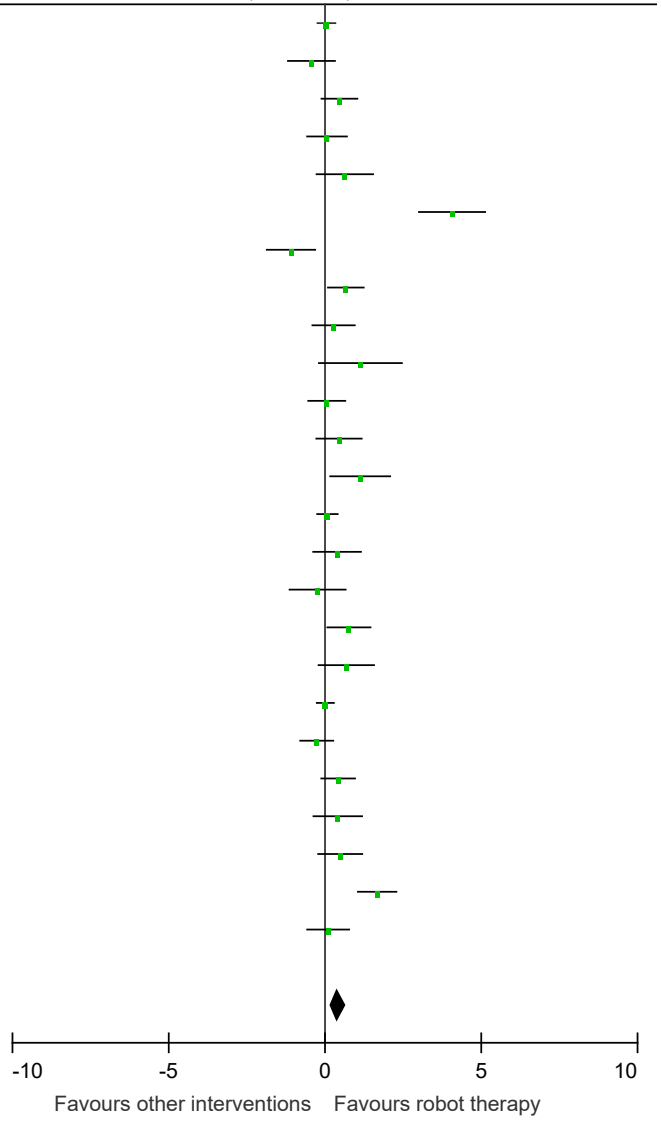


Figure 7: Activities of daily living (Barthel index, functional independence measure, Motor activity log [different scale ranges], higher values are better, final values) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Chen 2021B	71	12.82	10	66	11.91	10	2.1%	0.39 [-0.50, 1.27]
Daunoraviciene 2018	31.94	4.39	17	27.76	7.62	17	3.5%	0.66 [-0.04, 1.35]
Gueye 2021	110.8	8.17	25	104.9	15.49	25	5.3%	0.47 [-0.09, 1.03]
Hsieh 2011	0.1	0.2	12	0.1	0.3	6	1.8%	0.00 [-0.98, 0.98]
Jiang 2021	93.39	15.99	23	84.55	12.7	22	4.7%	0.60 [0.00, 1.20]
Rabadi 2008	25.5	7.2	10	28.3	6.7	20	2.9%	-0.40 [-1.16, 0.37]
Rodgers 2019	15.5	3.4	232	15.3	3.6	437	66.5%	0.06 [-0.10, 0.22]
Singh 2021	89.1	7.9	12	82.7	14.3	11	2.4%	0.54 [-0.30, 1.38]
Taravati 2021	96.47	23.55	17	93.15	21.99	20	4.0%	0.14 [-0.50, 0.79]
Xu 2020	54.8	20.2	20	53.3	16.2	20	4.4%	0.08 [-0.54, 0.70]
Yoo 2013	77.9	9.7	11	75.4	5.1	11	2.4%	0.31 [-0.53, 1.15]
Total (95% CI)			**389**			**599**	**100.0%**	**0.14 [0.01, 0.27]**

Heterogeneity: Chi² = 10.11, df = 10 (P = 0.43); I² = 1%
Test for overall effect: Z = 2.12 (P = 0.03)

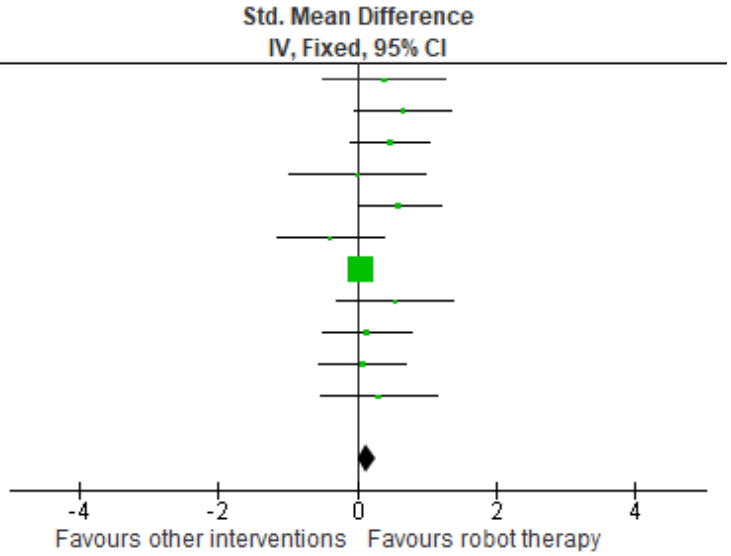


Figure 8: Activities of daily living (Barthel index, functional independence measure, Motor activity log [different scale ranges], higher values are better, change scores) at ≥6 months

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Burgar 2011	25.7	10.6	25	26.8	10.73872	12	7.3%	-0.10 [-0.79, 0.59]
Hesse 2014	37.1	16.9	25	29.3	21.4	25	11.1%	0.40 [-0.16, 0.96]
Housman 2009	0.4	0.7	14	0.3	0.4	14	6.3%	0.17 [-0.57, 0.91]
Lum 2002	2.1	4.687217	13	0.4	1.496663	14	5.9%	0.48 [-0.29, 1.25]
Lum 2006	4	5.9	18	5.2	3.8	5	3.5%	-0.21 [-1.20, 0.79]
Masiero 2007	46.2	10.4	17	31.8	14.6	18	6.8%	1.10 [0.39, 1.82]
Masiero 2011	1.8	1.4	11	0.25	0.5	10	3.7%	1.39 [0.41, 2.36]
Remy-Neris 2021	18.51	13.3	97	18.65	14.75	97	44.0%	-0.01 [-0.29, 0.27]
Taveggia 2016	21.4	17.9	27	6.3	20.4	27	11.3%	0.78 [0.22, 1.33]
Total (95% CI)			**247**			**222**	**100.0%**	**0.28 [0.09, 0.46]**

Heterogeneity: Chi² = 19.80, df = 8 (P = 0.01); I² = 60%
Test for overall effect: Z = 2.92 (P = 0.004)

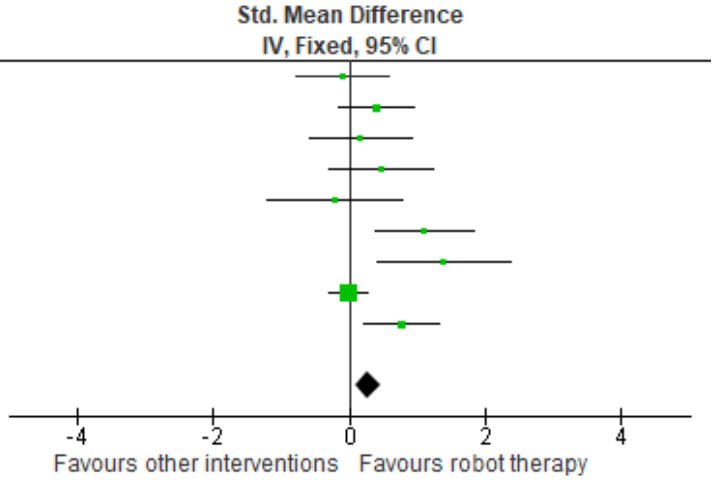


Figure 9: Activities of daily living (Barthel index, Functional Independence Measure [different scale ranges], higher values are better, final values) at ≥6 months

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Jiang 2021	95.48	15.85	23	86.45	13.25	22	7.0%	0.61 [0.01, 1.21]
Rodgers 2019	15.6	3.4	221	15.7	3.6	404	93.0%	-0.03 [-0.19, 0.14]
Total (95% CI)			**244**			**426**	**100.0%**	**0.02 [-0.14, 0.17]**

Heterogeneity: Chi² = 4.01, df = 1 (P = 0.05); I² = 75%
Test for overall effect: Z = 0.20 (P = 0.84)

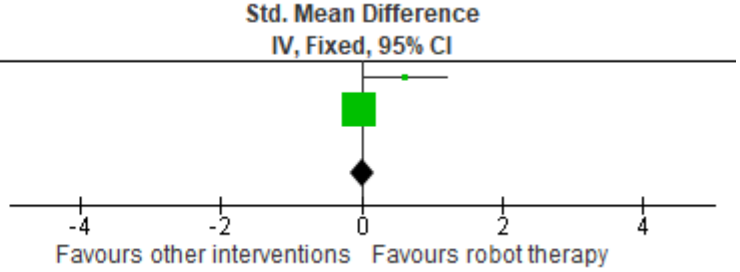


Figure 10: Arm function (FMA UE, Quick DASH, manual function test [different scale ranges], higher values are better, change scores) at end of intervention

Study or Subgroup	Std. Mean Difference	SE	Robot arm training Total	Other interventions Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Ang 2014	0.6257	0.4694	15	7	0.9%	0.63 [-0.29, 1.55]
Aprile 2020	-0.0086	0.1452	91	99	9.5%	-0.01 [-0.29, 0.28]
Bishop 2014	-0.245	0.3796	14	14	1.4%	-0.24 [-0.99, 0.50]
Brokaw 2014	0.2769	0.5896	7	5	0.6%	0.28 [-0.88, 1.43]
Burgar 2011	-0.0875	0.2888	36	18	2.4%	-0.09 [-0.65, 0.48]
Carpinella 2020	0.0986	0.3247	19	19	1.9%	0.10 [-0.54, 0.74]
Chen 2021A	1.0302	0.4827	10	10	0.9%	1.03 [0.08, 1.98]
Chinembiri 2021	2.6827	0.4215	20	25	1.1%	2.68 [1.86, 3.51]
Conroy 2011	0.3214	0.27	41	21	2.7%	0.32 [-0.21, 0.85]
Coskunsu 2022	-0.3089	0.4528	11	9	1.0%	-0.31 [-1.20, 0.58]
Daly 2005	-0.1586	0.5576	7	6	0.6%	-0.16 [-1.25, 0.93]
Fazekas 2007	1.7963	0.4419	15	15	1.0%	1.80 [0.93, 2.66]
Frisoli 2022	0.1335	0.427	11	11	1.1%	0.13 [-0.70, 0.97]
Gandolfi 2019	-0.6422	0.3638	16	16	1.5%	-0.64 [-1.36, 0.07]
Grigoras 2016	-0.3055	0.4031	13	12	1.2%	-0.31 [-1.10, 0.48]
Hesse 2014	-0.3159	0.2848	25	25	2.5%	-0.32 [-0.87, 0.24]
Hollenstein 2011	-0.0699	0.5566	7	6	0.6%	-0.07 [-1.16, 1.02]
Housman 2009	0.4293	0.3474	17	17	1.7%	0.43 [-0.25, 1.11]
Hsieh 2014	0.6444	0.3138	32	16	2.0%	0.64 [0.03, 1.26]
Hwang 2012	0.4883	0.5372	9	6	0.7%	0.49 [-0.56, 1.54]
Kim 2021	0.2732	0.2933	23	24	2.3%	0.27 [-0.30, 0.85]
Lee 2016	0.2371	0.3027	22	22	2.2%	0.24 [-0.36, 0.83]
Lee 2018	0.8765	0.3848	15	15	1.4%	0.88 [0.12, 1.63]
Liao 2012	0.6994	0.4639	10	10	0.9%	0.70 [-0.21, 1.61]
Lin 2022	0.2118	0.1671	72	72	7.2%	0.21 [-0.12, 0.54]
Lo 2010	0.57	0.1859	49	78	5.8%	0.57 [0.21, 0.93]
Lum 2002	0.391	0.3894	13	14	1.3%	0.39 [-0.37, 1.15]
Lum 2006	0.2503	0.4578	24	6	1.0%	0.25 [-0.65, 1.15]
Marganska 2014	0.4659	0.2312	39	38	3.7%	0.47 [0.01, 0.92]
Masiero 2007	0.519	0.3445	17	18	1.7%	0.52 [-0.16, 1.19]
Masiero 2011	-0.1765	0.438	11	10	1.0%	-0.18 [-1.03, 0.68]
Mayr 2008	0.6578	0.7438	4	4	0.4%	0.66 [-0.80, 2.12]
McCabe 2015	-0.362	0.3496	12	27	1.6%	-0.36 [-1.05, 0.32]
Orihuela-Espina 2016	1.5811	0.576	9	8	0.6%	1.58 [0.45, 2.71]
Rabadi 2008	-0.1065	0.3876	10	20	1.3%	-0.11 [-0.87, 0.65]
Ranzani 2020	0.0508	0.3852	14	13	1.4%	0.05 [-0.70, 0.81]
Remy-Neris 2021	0.1717	0.1389	105	103	10.4%	0.17 [-0.10, 0.44]
Sale 2014	0.542	0.2802	26	27	2.6%	0.54 [-0.01, 1.09]
Susanto 2015	-0.1034	0.4599	9	10	0.9%	-0.10 [-1.00, 0.80]
Takahashi 2016	0.3078	0.2696	30	26	2.8%	0.31 [-0.22, 0.84]
Takebayashi 2022	1.3804	0.2203	81	36	4.1%	1.38 [0.95, 1.81]
Timmermans 2014	-0.0751	0.4266	11	11	1.1%	-0.08 [-0.91, 0.76]
Tomic 2017	1.3204	0.4397	13	13	1.0%	1.32 [0.46, 2.18]
Valles 2016	-0.1107	0.4476	10	10	1.0%	-0.11 [-0.99, 0.77]
Vanoglio 2017	1.0118	0.413	14	13	1.2%	1.01 [0.20, 1.82]
Villafane 2017	0.4104	0.3578	16	16	1.6%	0.41 [-0.29, 1.11]
Volpe 2000	0.7009	0.2766	30	26	2.6%	0.70 [0.16, 1.24]
Zengin-Metli 2018	1.06	0.3671	20	15	1.5%	1.06 [0.34, 1.78]
Total (95% CI)			**1125**	**1042**	**100.0%**	**0.34 [0.26, 0.43]**

Heterogeneity: Chi² = 132.92, df = 47 (P < 0.00001); I² = 65%

Test for overall effect: Z = 7.69 (P < 0.00001)

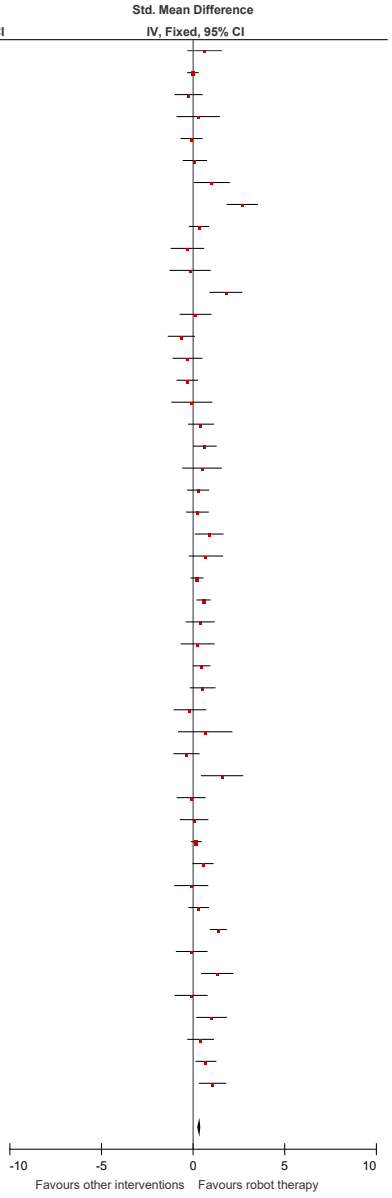


Figure 11: Arm function (FMA UE, Chedoke Arm and Hand Activity [different scale ranges], higher values are better, final values) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Abdullah 2011	2.75	1.8	9	1	1.69	11	1.3%	0.96 [0.02, 1.91]
Budhota 2021	44.64	9.77	22	38.86	11.69	22	3.1%	0.53 [-0.08, 1.13]
Calabro 2019	36	4	25	34	4	25	3.5%	0.49 [-0.07, 1.06]
Chen 2021B	35.1	13.36	10	28.7	11.27	10	1.4%	0.50 [-0.40, 1.39]
Chen 2022	35.64	9.3	14	38.8	10.32	10	1.7%	-0.31 [-1.13, 0.50]
Daunoraviciene 2018	45.17	18.48	17	41.76	15.41	17	2.4%	0.20 [-0.48, 0.87]
Dehem 2019	51.9	30.9	15	42.4	32.6	17	2.3%	0.29 [-0.41, 0.99]
Gueye 2021	54.5	10.06	25	54.2	13.93	25	3.6%	0.02 [-0.53, 0.58]
Hesse 2005	24.6	14.9	22	10.4	7.5	22	2.7%	1.18 [0.54, 1.83]
Hsieh 2011	4.2	5.9	12	2.8	7.4	6	1.2%	0.21 [-0.77, 1.19]
Hsu 2019	43.1	13	22	44.1	15.9	21	3.1%	-0.07 [-0.67, 0.53]
Hsu 2021	42.1	14.4	17	27.6	12.6	15	2.0%	1.04 [0.29, 1.79]
Hung 2022	36.46	8.88	13	34.41	9.8	24	2.4%	0.21 [-0.47, 0.89]
Jiang 2021	45.61	8.83	23	39.32	8.17	22	3.0%	0.73 [0.12, 1.33]
Kim 2019	-68	6	19	-83	8	19	1.7%	2.08 [1.27, 2.88]
Ma 2022	36.4	16.87	10	30.11	20.95	9	1.4%	0.32 [-0.59, 1.23]
Rodgers 2019	76.6	22.1	232	76.1	23.2	437	43.9%	0.02 [-0.14, 0.18]
Singh 2021	50.2	6.5	12	45.5	9.7	11	1.6%	0.55 [-0.28, 1.39]
Taravati 2021	24.24	10.02	17	23.35	10.01	20	2.7%	0.09 [-0.56, 0.73]
Volpe 2008	15.73	6.6	11	15.1	5.3	10	1.5%	0.10 [-0.76, 0.96]
Wolf 2015	43.4	44.07	47	42.9	42.6	45	6.7%	0.01 [-0.40, 0.42]
Wu 2012	47.14	10.97	14	48.64	11.4	28	2.7%	-0.13 [-0.77, 0.51]
Xu 2020	31.8	10	20	35.4	9.1	20	2.8%	-0.37 [-0.99, 0.26]
Yoo 2013	43.4	15.9	11	33.3	6.3	11	1.5%	0.80 [-0.07, 1.68]
Total (95% CI)			**639**			**857**	**100.0%**	**0.20 [0.09, 0.31]**

Heterogeneity: Chi² = 57.99, df = 23 (P < 0.0001); I² = 60%

Test for overall effect: Z = 3.72 (P = 0.0002)

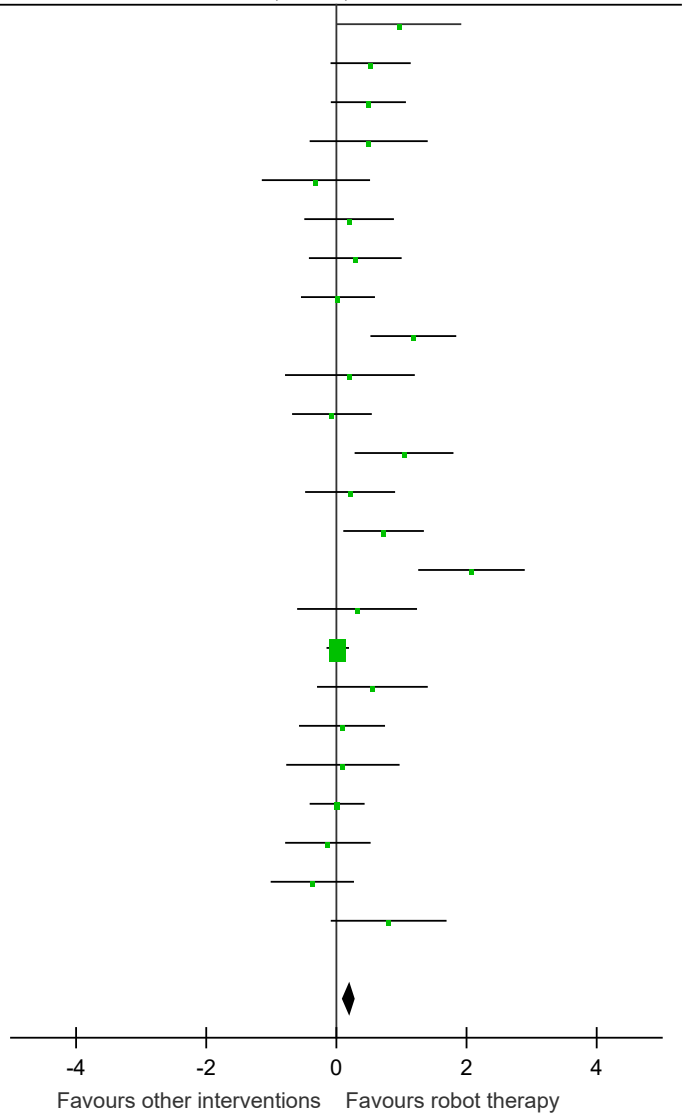


Figure 12: Arm function (FMA UE, 0-66, higher values are better, change scores) at ≥6 months

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Ang 2014	9.2	3.8	15	3.6	5.9	7	4.3%	5.60 [0.82, 10.38]
Burgar 2011	23.1	19.4	25	15.3	58.88973	12	0.1%	7.80 [-26.38, 41.98]
Conroy 2011	2.97	3.531963	41	1.82	3.574409	21	27.8%	1.15 [-0.72, 3.02]
Hesse 2014	16.8	16	25	20.2	14.6	25	1.4%	-3.40 [-11.89, 5.09]
Housman 2009	3.6	2.9	14	1.5	2.7	14	22.6%	2.10 [0.02, 4.18]
Lum 2002	2.45	3	13	2.4	2.7	14	20.9%	0.05 [-2.11, 2.21]
Lum 2006	5.7	4.7	24	6.9	4.5	6	5.9%	-1.20 [-5.26, 2.86]
Masiero 2011	12.5	8.9	11	14.21	7.1	10	2.1%	-1.71 [-8.57, 5.15]
Ranzani 2020	8.64	7.42	14	8.08	8.32	13	2.7%	0.56 [-5.40, 6.52]
Remy-Neris 2021	23.44	11.09	97	22.41	10.53	97	10.5%	1.03 [-2.01, 4.07]
Susanto 2015	6.1	10.9	9	2.7	4.4	10	1.7%	3.40 [-4.23, 11.03]
Total (95% CI)			**288**			**229**	**100.0%**	**1.08 [0.09, 2.07]**

Heterogeneity: Chi² = 8.70, df = 10 (P = 0.56); I² = 0%
Test for overall effect: Z = 2.14 (P = 0.03)

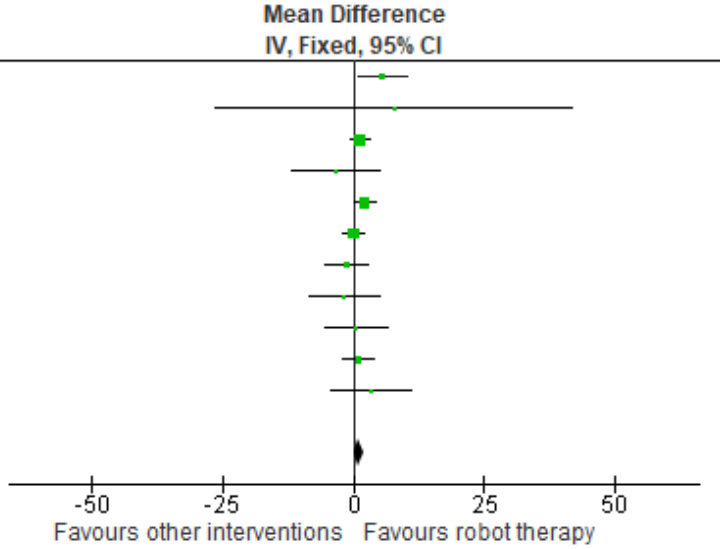


Figure 13: Arm function (FMA UE, Korean DASH [different scale ranges], higher values are better, final values) at ≥6 months

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Budhota 2021	45.33	11.43	21	40.36	11.57	22	11.4%	0.42 [-0.18, 1.03]
Dehem 2019	57.1	33.8	15	41.6	34.5	13	10.1%	0.44 [-0.31, 1.19]
Hesse 2005	30	16.8	19	16.6	14.9	20	10.9%	0.83 [0.17, 1.49]
Hsu 2019	45.2	13.6	22	44.9	14.5	21	11.4%	0.02 [-0.58, 0.62]
Hsu 2021	44.3	13.7	17	26.7	13.2	15	9.9%	1.27 [0.50, 2.04]
Hung 2022	34.92	7.25	13	34.33	9.84	24	10.8%	0.06 [-0.61, 0.74]
Jiang 2021	48.87	8.63	23	41.91	7.71	22	11.3%	0.83 [0.22, 1.45]
Kim 2019	-65	6	19	-82	10	19	9.7%	2.02 [1.22, 2.81]
Rodgers 2019	78.2	22.8	221	78.7	23.7	404	14.4%	-0.02 [-0.19, 0.14]
Total (95% CI)			**370**			**560**	**100.0%**	**0.61 [0.18, 1.03]**

Heterogeneity: Tau² = 0.32; Chi² = 43.56, df = 8 (P < 0.00001); I² = 82%

Test for overall effect: Z = 2.80 (P = 0.005)

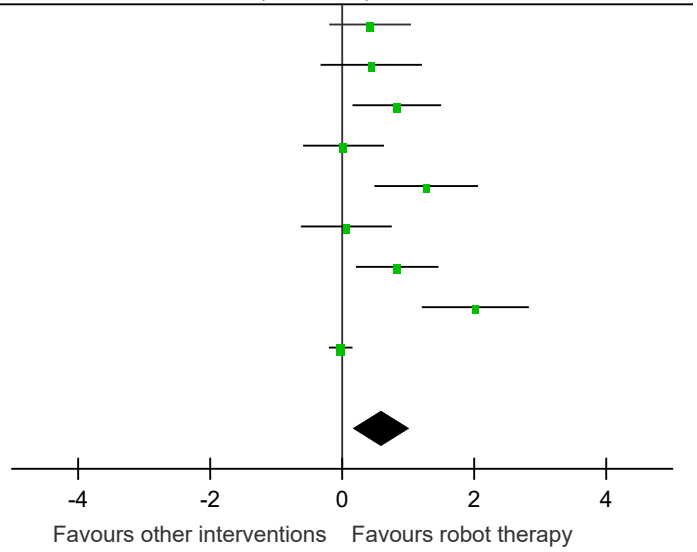


Figure 14: Arm muscle strength (Motricity index, MRC, manual muscle test, MRC total motor power [different scale ranges], higher values are better, change scores) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Aprile 2020	17.35	14.38106	91	12.92	14.38983	99	6.4%	0.31 [0.02, 0.59]
Bishop 2014	0.84	5.3	14	1.63	7.8	14	4.6%	-0.12 [-0.86, 0.63]
Burgar 2011	14.9	11.16	36	15.4	15.69777	18	5.3%	-0.04 [-0.60, 0.53]
Gandolfi 2019	3.62	2.739919	16	0.9	2.289522	16	4.6%	1.05 [0.30, 1.80]
Hesse 2014	7.5	7.1	25	8.1	6.4	25	5.4%	-0.09 [-0.64, 0.47]
Iwamoto 2019	2.75	7.19	6	1.67	4.66	5	3.0%	0.16 [-1.03, 1.35]
Kim 2021	5.74	9.49	23	0.54	1.89	24	5.2%	0.76 [0.16, 1.35]
Lee 2016	0.3	0.5	22	0.2	0.4	22	5.2%	0.22 [-0.38, 0.81]
Lum 2006	7.9	7.5	24	9.3	3.2	6	4.0%	-0.20 [-1.09, 0.70]
Masiero 2007	1.7	1.2	17	1.2	1	18	4.9%	0.44 [-0.23, 1.12]
Masiero 2011	0.8	0.6	11	1.5	0.9	10	3.9%	-0.89 [-1.79, 0.02]
Orihuela-Espina 2016	12	7.8	9	5.3	6.6	8	3.6%	0.88 [-0.13, 1.89]
Rabadi 2008	8.3	7.9	10	1.2	9.6	20	4.4%	0.76 [-0.03, 1.55]
Sale 2014	13.9	15.5	26	9.3	21.7	27	5.4%	0.24 [-0.30, 0.78]
Takahashi 2016	6.5	11	30	8.4	13.7	26	5.5%	-0.15 [-0.68, 0.37]
Takebayashi 2022	6.99	2.32	81	5.28	1.95	36	6.0%	0.77 [0.36, 1.17]
Taveggia 2016	17.7	20.8	27	11.4	16	27	5.4%	0.33 [-0.20, 0.87]
Vanoglio 2017	23	17.9	14	5.2	10.2	13	4.2%	1.17 [0.35, 2.00]
Villafane 2017	24.4	2.6	16	14.9	2.6	16	3.1%	3.56 [2.40, 4.72]
Volpe 2000	4.1	1.4	30	1.7	1.7	26	5.2%	1.53 [0.93, 2.13]
Zengin-Metli 2018	21.5	3.87	20	22.87	5	15	4.9%	-0.31 [-0.98, 0.37]
Total (95% CI)			**548**			**471**	**100.0%**	**0.45 [0.17, 0.72]**

Heterogeneity: Tau² = 0.29; Chi² = 80.85, df = 20 (P < 0.00001); I² = 75%

Test for overall effect: Z = 3.18 (P = 0.001)

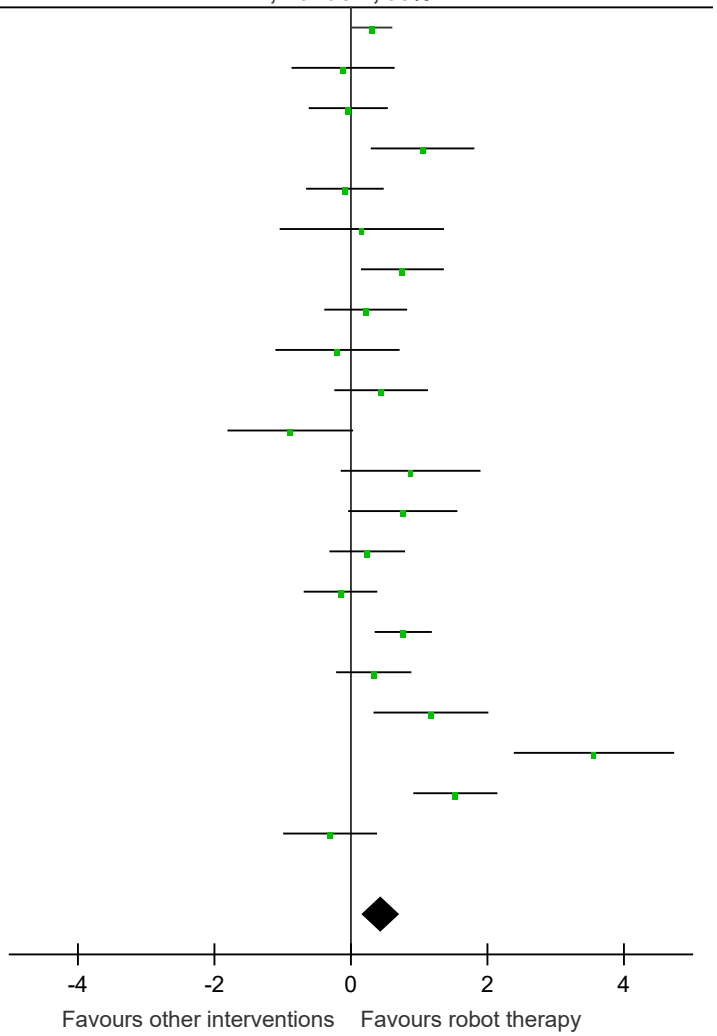


Figure 15: Arm muscle strength (Motricity index, MRC [different scale ranges], higher values are better, final values) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Hesse 2005	21.8	10.5	22	6.8	8.3	22	35.6%	1.56 [0.87, 2.24]
Hsieh 2011	3.5	0.5	12	3.3	0.7	6	26.0%	0.33 [-0.65, 1.32]
Jiang 2021	65.22	9.31	23	58.95	9.33	22	38.4%	0.66 [0.06, 1.26]
Total (95% CI)			**57**			**50**	**100.0%**	**0.89 [0.19, 1.60]**

Heterogeneity: Tau² = 0.24; Chi² = 5.41, df = 2 (P = 0.07); I² = 63%
Test for overall effect: Z = 2.50 (P = 0.01)

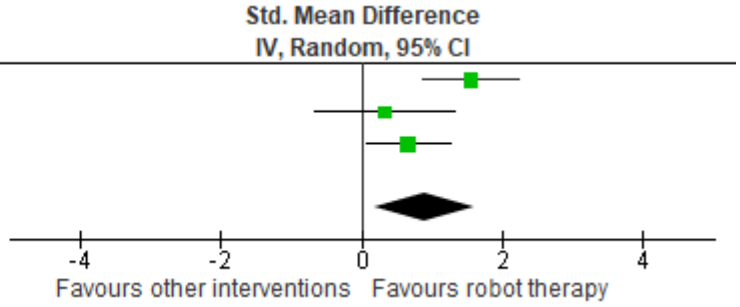


Figure 16: Arm muscle strength (grip strength [kg], higher values are better, change scores and final values) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Budhota 2021	9.41	4.84	22	7.81	3.7	22	26.3%	1.60 [-0.95, 4.15]
Housman 2009	0.8	3	17	0.8	2.3	17	52.7%	0.00 [-1.80, 1.80]
Hwang 2012	1.7	7	9	1.3	6.3	6	3.7%	0.40 [-6.41, 7.21]
Mayr 2008	3.6	4.4	4	2.4	4.2	4	4.8%	1.20 [-4.76, 7.16]
Yoo 2013	8.5	5.8	11	5.1	2.3	11	12.5%	3.40 [-0.29, 7.09]
Total (95% CI)			**63**			**60**	**100.0%**	**0.92 [-0.39, 2.22]**

Heterogeneity: Chi² = 3.05, df = 4 (P = 0.55); I² = 0%
Test for overall effect: Z = 1.38 (P = 0.17)

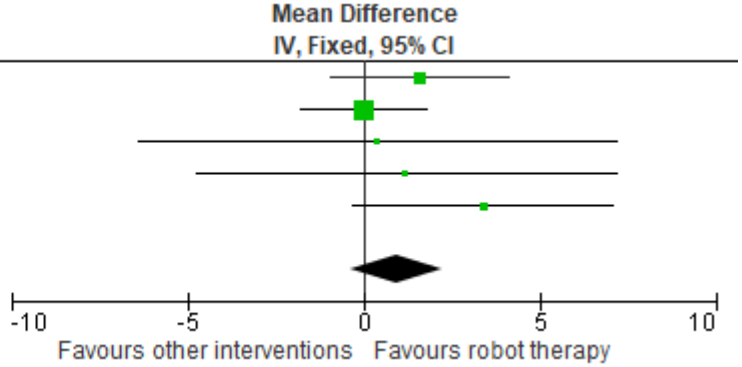


Figure 17: Arm muscle strength (grip strength [Newton meter], higher values are better, change score and final value) at end of intervention

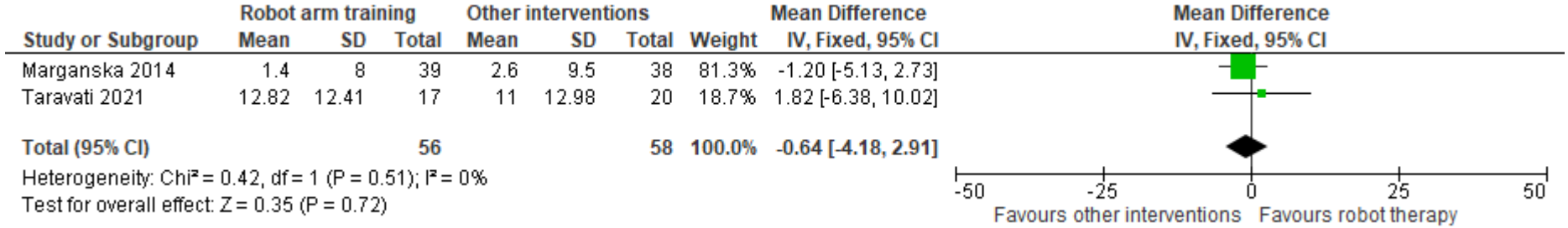


Figure 18: Arm muscle strength (MRC total, MRC total motor power [different scale ranges], higher values are better, change scores) at ≥6 months

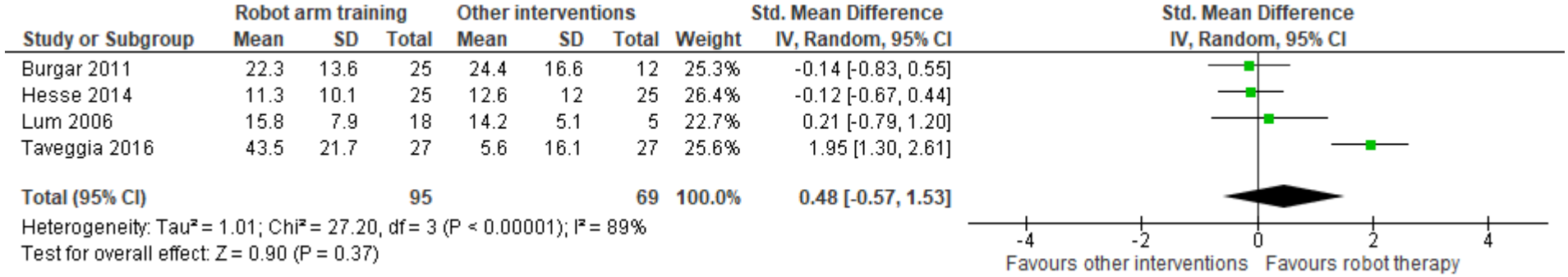


Figure 19: Arm muscle strength (MRC total, MI [different scale ranges], higher values are better, final value) at ≥6 months

Study or Subgroup	Robot arm training Mean	SD	Total	Other interventions Mean	SD	Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Hesse 2005	22.6	11.1	19	7.9	9	20	42.2%	1.43 [0.72, 2.14]
Jiang 2021	68.87	8.64	23	61.86	9.13	22	57.8%	0.78 [0.17, 1.38]
Total (95% CI)			**42**			**42**	**100.0%**	**1.05 [0.59, 1.51]**

Heterogeneity: Chi² = 1.87, df = 1 (P = 0.17); I² = 47%
Test for overall effect: Z = 4.46 (P < 0.00001)

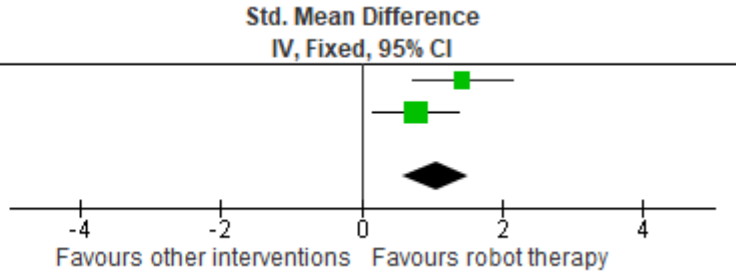


Figure 20: Arm muscle strength (grip strength [kg], higher values are better, change score and final value) at ≥6 months

Study or Subgroup	Robot arm training Mean	SD	Total	Other interventions Mean	SD	Total	Weight	Mean Difference IV, Fixed, 95% CI
Budhota 2021	10.86	6.28	21	8.94	4.01	22	43.3%	1.92 [-1.25, 5.09]
Housman 2009	1.8	4.8	14	1.4	2.2	14	56.7%	0.40 [-2.37, 3.17]
Total (95% CI)			**35**			**36**	**100.0%**	**1.06 [-1.02, 3.14]**

Heterogeneity: Chi² = 0.50, df = 1 (P = 0.48); I² = 0%
Test for overall effect: Z = 1.00 (P = 0.32)

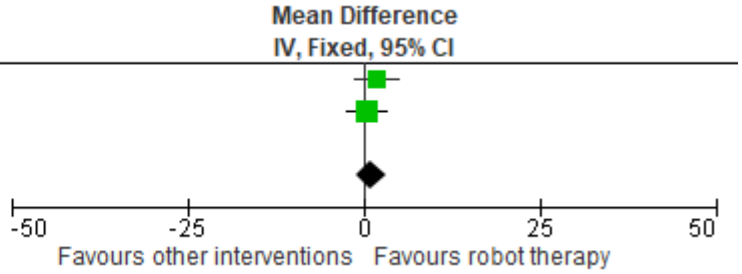


Figure 21: Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Burgar 2011	0.09	0.12	36	0.11	0.4	18	7.1%	-0.08 [-0.65, 0.49]
Fazekas 2007	-0.74	1	15	-0.1	0.9	15	5.4%	-0.65 [-1.39, 0.08]
Frisoli 2022	1.5	13.7	11	1.4	11.5	11	4.6%	0.01 [-0.83, 0.84]
Gandolfi 2019	3.62	3.48	16	6.56	5.26	16	5.6%	-0.64 [-1.36, 0.07]
Hesse 2014	0.1	3.6	25	0.2	4.1	25	7.2%	-0.03 [-0.58, 0.53]
Hwang 2012	1	0.7	9	0.9	0.8	6	3.4%	0.13 [-0.91, 1.16]
Kim 2021	-0.13	0.37	23	-0.013	0.25	24	6.9%	-0.37 [-0.94, 0.21]
Lee 2016	-0.4	0.5	22	-0.23	0.43	22	6.7%	-0.36 [-0.95, 0.24]
Lo 2010	-0.07	0.09	49	0.06	0.5	78	9.7%	-0.33 [-0.69, 0.03]
Lum 2006	-0.21	0.6	24	0.3	1.8	6	4.1%	-0.53 [-1.44, 0.38]
Masiero 2007	0.13	1.4	17	0.13	0.9	18	6.1%	0.00 [-0.66, 0.66]
Masiero 2011	0.83	0.28	11	0.5	0.7	10	4.3%	0.61 [-0.27, 1.49]
Ranzani 2020	0.07	2.37	14	-1.54	2.91	13	5.1%	0.59 [-0.18, 1.36]
Takahashi 2016	-0.1	2.26	30	-0.4	1.66	26	7.5%	0.15 [-0.38, 0.67]
Takebayashi 2022	-0.73	0.75	81	0.07	0.69	36	8.9%	-1.09 [-1.50, -0.67]
Taveggia 2016	-1.6	1.5	27	-1	1.6	27	7.4%	-0.38 [-0.92, 0.16]
Total (95% CI)			**410**			**351**	**100.0%**	**-0.23 [-0.46, -0.01]**

Heterogeneity: Tau² = 0.10; Chi² = 31.24, df = 15 (P = 0.008); I² = 52%

Test for overall effect: Z = 2.05 (P = 0.04)

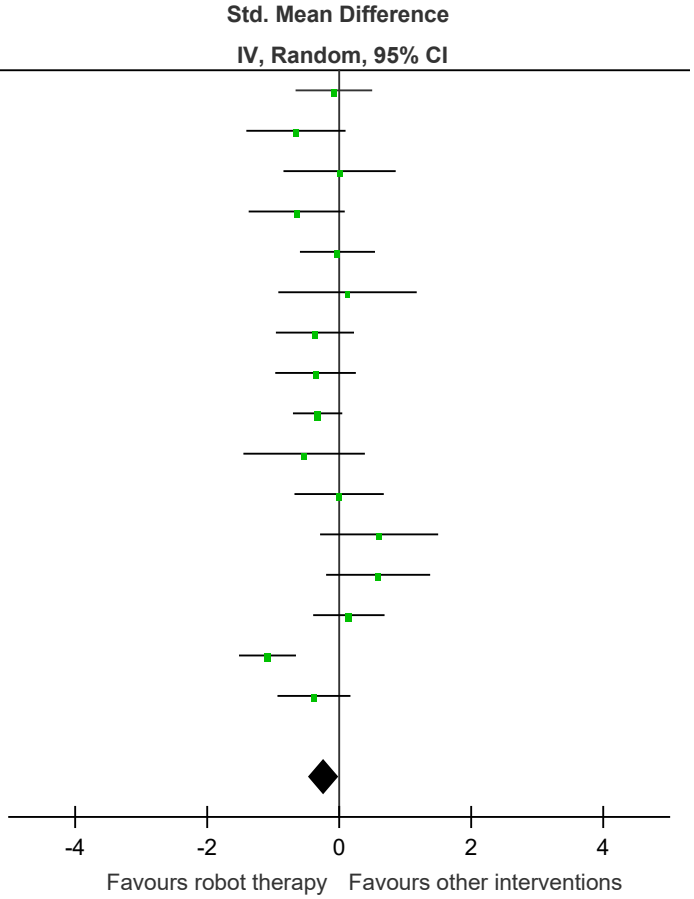


Figure 22: Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Fixed, 95% CI**
Daunoraviciene 2018	0.59	0.97	17	0.85	1.1	17	9.8%	-0.24 [-0.92, 0.43]
Hesse 2005	1.7	2.4	22	1.8	1.7	22	12.8%	-0.05 [-0.64, 0.54]
Hsu 2021	0.94	0.7	17	1.43	0.56	15	8.6%	-0.75 [-1.47, -0.03]
Hung 2022	1.16	0.91	13	1.29	0.9	24	9.8%	-0.14 [-0.82, 0.54]
Jiang 2021	1.13	0.9	23	1.32	1.02	22	13.0%	-0.19 [-0.78, 0.39]
Rabadi 2008	2.73	1.29	10	2.29	1.53	20	7.7%	0.29 [-0.47, 1.06]
Sale 2014	0.73	1.02	26	1	1.1	27	15.3%	-0.25 [-0.79, 0.29]
Singh 2021	1.29	0.2	12	1.59	0.6	11	6.3%	-0.66 [-1.50, 0.19]
Taravati 2021	0.52	0.7	17	0.68	0.78	20	10.6%	-0.21 [-0.86, 0.44]
Volpe 2008	6.27	3.316625	11	6	4.110961	10	6.1%	0.07 [-0.79, 0.93]
Total (95% CI)			**168**			**188**	**100.0%**	**-0.21 [-0.42, 0.00]**

Heterogeneity: Chi² = 5.67, df = 9 (P = 0.77); I² = 0%

Test for overall effect: Z = 1.93 (P = 0.05)

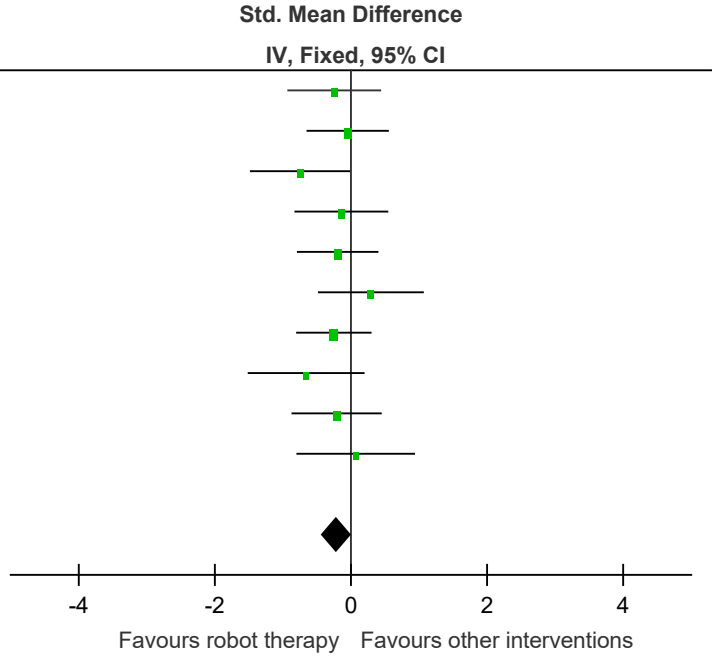


Figure 23: Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at ≥6 months

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Burgar 2011	0.4	0.5	25	0.16	0.5	12	13.7%	0.47 [-0.23, 1.17]
Hesse 2014	0.6	4.9	25	0.6	5.5	25	21.7%	0.00 [-0.55, 0.55]
Lum 2006	-3	3	18	0.5	1.7	5	5.9%	-1.21 [-2.27, -0.14]
Masiero 2007	0.13	1.4	17	0.88	1.4	18	14.6%	-0.52 [-1.20, 0.15]
Masiero 2011	0.55	0.8	11	0.75	1.2	10	9.1%	-0.19 [-1.05, 0.67]
Ranzani 2020	-0.21	2.36	14	-1.31	3.12	13	11.5%	0.39 [-0.38, 1.15]
Taveggia 2016	-1.6	1.5	27	-1.4	1.6	27	23.4%	-0.13 [-0.66, 0.41]
Total (95% CI)			**137**			**110**	**100.0%**	**-0.09 [-0.34, 0.17]**

Heterogeneity: Chi² = 9.97, df = 6 (P = 0.13); I² = 40%
Test for overall effect: Z = 0.65 (P = 0.51)

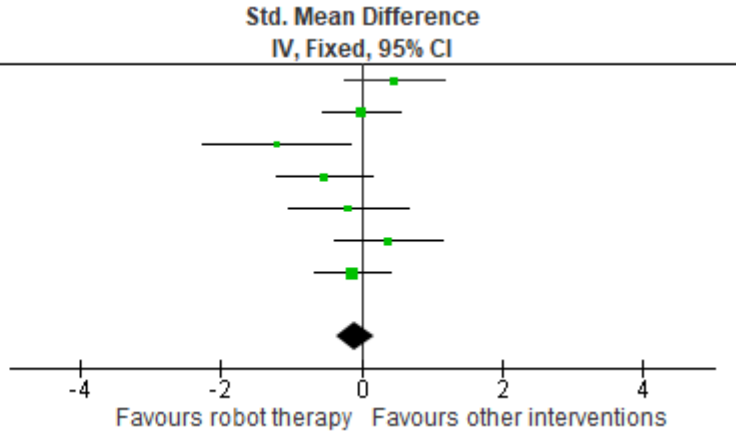


Figure 24: Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at ≥6 months

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Hesse 2005	1.4	2.6	19	1.8	1.7	20	26.3%	-0.18 [-0.81, 0.45]
Hsu 2021	0.85	0.7	17	1.3	0.72	15	20.5%	-0.62 [-1.33, 0.09]
Hung 2022	1.49	0.99	13	1.54	0.8	24	22.8%	-0.06 [-0.73, 0.62]
Jiang 2021	1.09	1.06	23	1.14	0.87	22	30.4%	-0.05 [-0.64, 0.53]
Total (95% CI)			**72**			**81**	**100.0%**	**-0.20 [-0.52, 0.12]**

Heterogeneity: Chi² = 1.75, df = 3 (P = 0.63); I² = 0%
Test for overall effect: Z = 1.23 (P = 0.22)

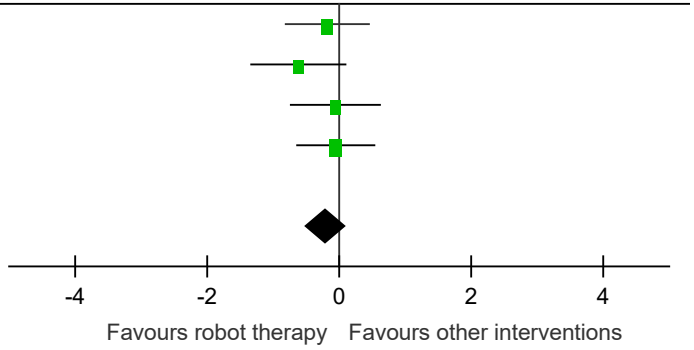


Figure 25: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, change scores and final values) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI
Conroy 2011	3.98	11.97384	41	-3.19	11.27314	21	20.0%	7.17 [1.11, 13.23]
Dehem 2019	50	21.4	15	50.9	34.7	17	1.9%	-0.90 [-20.63, 18.83]
Lo 2010	6.3	11.8	49	1.4	12.1	78	40.4%	4.90 [0.64, 9.16]
Volpe 2008	67.1	7.959899	11	65.5	7.589466	10	16.6%	1.60 [-5.05, 8.25]
Wu 2012	73.97	8.68	14	66.18	10.11	28	21.1%	7.79 [1.90, 13.68]
Total (95% CI)			**130**			**154**	**100.0%**	**5.31 [2.60, 8.02]**

Heterogeneity: Chi² = 2.65, df = 4 (P = 0.62); I² = 0%
Test for overall effect: Z = 3.84 (P = 0.0001)

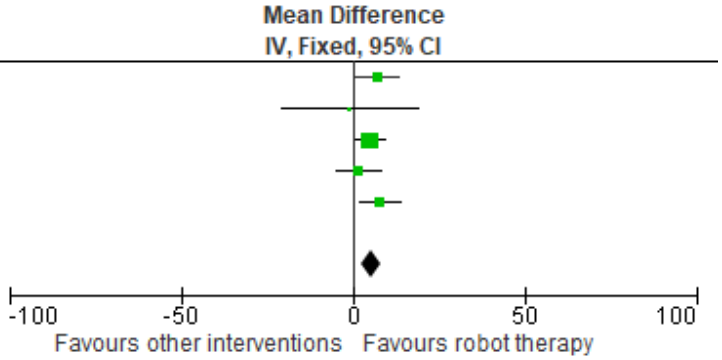


Figure 26: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain [different scale ranges], higher values are better, change scores) at end of intervention

	Robot arm training			Other interventions				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Grigoras 2016	4.3	0.85	13	3.5	0.98	12	19.7%	0.85 [0.02, 1.67]
Hwang 2012	47.6	7.5	9	47	6.2	6	18.5%	0.08 [-0.95, 1.11]
Kutner 2010	26.47	16.47429	10	14.85	15.36472	7	18.7%	0.69 [-0.31, 1.69]
Remy-Neris 2021	14.79	24.41	105	14.99	21.43	103	21.8%	-0.01 [-0.28, 0.26]
Takebayashi 2022	9.33	2.7	81	3.06	2.65	36	21.2%	2.32 [1.82, 2.82]
Total (95% CI)			**218**			**164**	**100.0%**	**0.80 [-0.31, 1.91]**

Heterogeneity: Tau² = 1.44; Chi² = 66.59, df = 4 (P < 0.00001); I² = 94%
Test for overall effect: Z = 1.42 (P = 0.16)

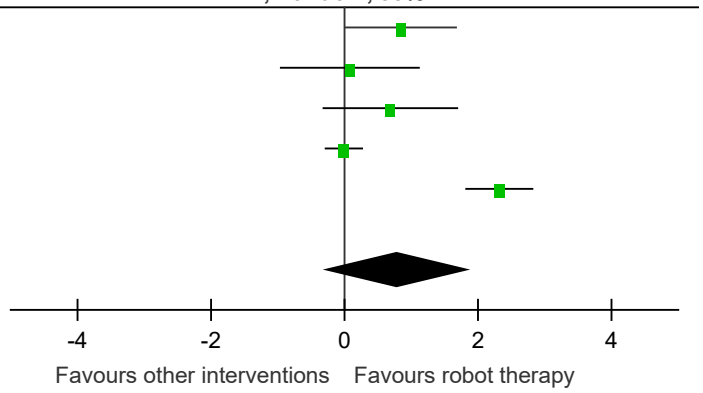


Figure 27: Stroke-specific Patient-Reported Outcome Measures (SS-QOL, 49-245, higher values are better, final value) at end of intervention

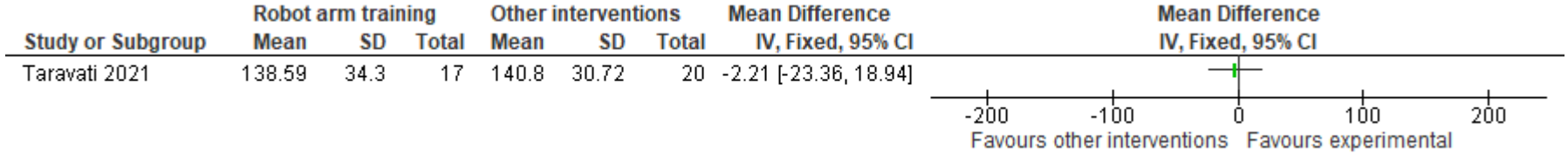


Figure 28: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - strength domain, 0-100, higher values are better, change score) at end of intervention

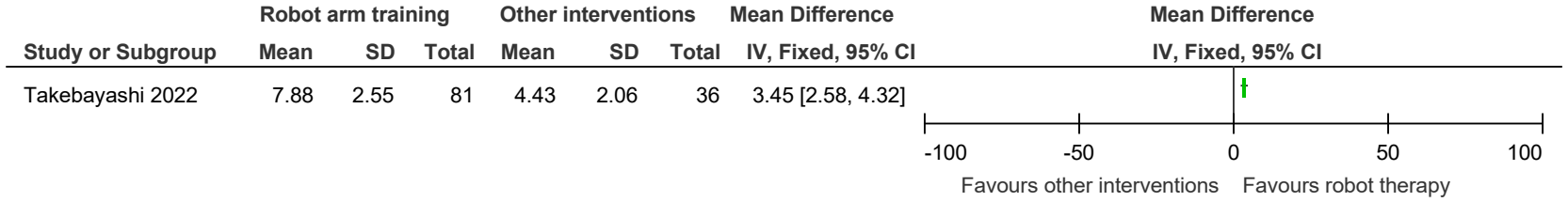


Figure 29: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - memory domain, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Takebayashi 2022	1.59	2.1	81	1.4	1.67	36	0.19 [-0.52, 0.90]	

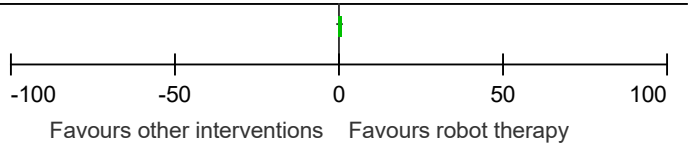


Figure 30: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - emotion domain, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Takebayashi 2022	-0.46	1.17	81	0.78	1.18	36	-1.24 [-1.70, -0.78]	

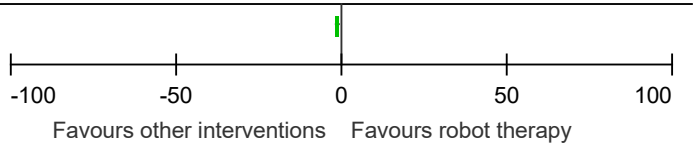


Figure 31: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - communication domain, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions			Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	IV, Fixed, 95% CI
Takebayashi 2022	0.67	1.49	81	0.99	1.6	36	-0.32 [-0.94, 0.30]

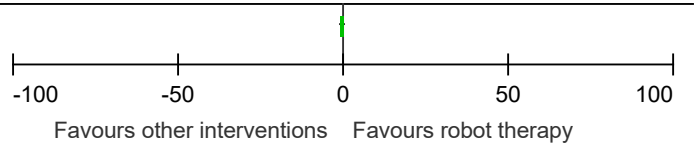


Figure 32: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, 0-100, higher values are better, change scores and final value) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Kutner 2010	6.89	9.386923	10	8.49	8.763624	7	17.8%	-1.60 [-10.32, 7.12]
Rodgers 2019	50.8	22.5	213	53.5	21	395	36.2%	-2.70 [-6.36, 0.96]
Takebayashi 2022	3.52	1.76	81	0.52	1.76	36	46.0%	3.00 [2.31, 3.69]
Total (95% CI)			**304**			**438**	**100.0%**	**0.12 [-4.56, 4.80]**

Heterogeneity: Tau² = 12.24; Chi² = 9.96, df = 2 (P = 0.007); I² = 80%

Test for overall effect: Z = 0.05 (P = 0.96)

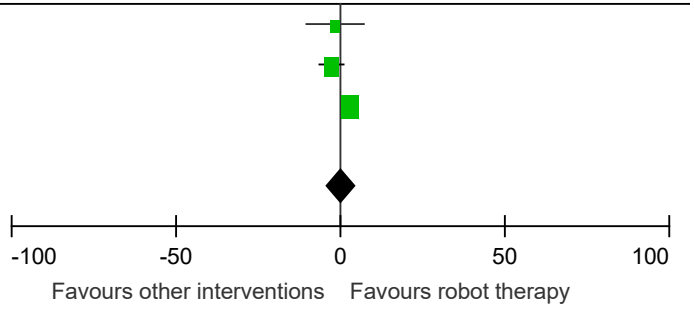


Figure 33: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, 0-100, higher values are better, change score and final value) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Rodgers 2019	61.6	25.1	213	63.9	24	395	39.6%	-2.30 [-6.42, 1.82]
Takebayashi 2022	2.74	1.76	81	0.5	1.86	36	60.4%	2.24 [1.52, 2.96]
Total (95% CI)			**294**			**431**	**100.0%**	**0.44 [-3.91, 4.79]**

Heterogeneity: Tau² = 8.03; Chi² = 4.53, df = 1 (P = 0.03); I² = 78%

Test for overall effect: Z = 0.20 (P = 0.84)

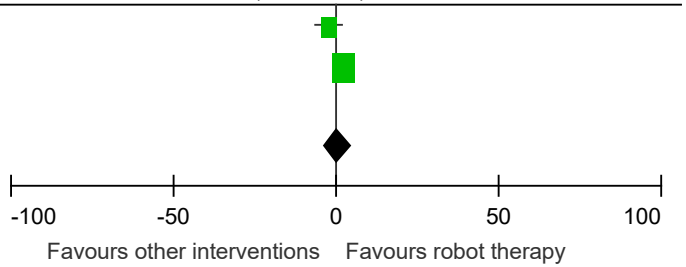


Figure 34: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social participation domain, 0-100, higher values are better, change score and final value) at end of intervention

	Robot arm training			Other interventions				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Rodgers 2019	47.7	24.7	210	49.6	23.4	394	47.6%	-1.90 [-5.96, 2.16]
Takebayashi 2022	8.45	3.07	81	1.37	3.23	36	52.4%	7.08 [5.83, 8.33]
Total (95% CI)			**291**			**430**	**100.0%**	**2.81 [-5.98, 11.60]**

Heterogeneity: Tau² = 37.97; Chi² = 17.15, df = 1 (P < 0.0001); I² = 94%

Test for overall effect: Z = 0.63 (P = 0.53)

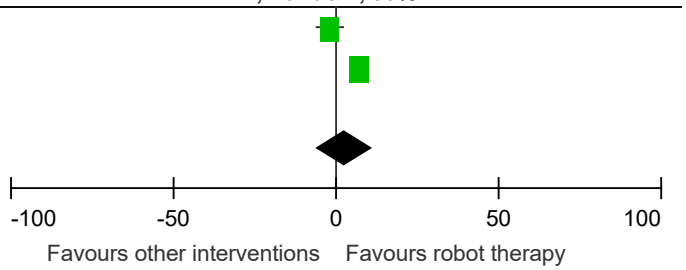


Figure 35: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - stroke recovery domain, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Takebayashi 2022	8.54	2.2	81	7.43	2.35	36	1.11 [0.21, 2.01]	

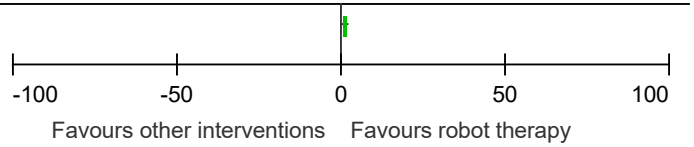


Figure 36: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - physical domain, 0-100, higher values are better, change score) at end of intervention

	Robot arm training			Other interventions			Mean Difference	Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	IV, Fixed, 95% CI	IV, Fixed, 95% CI
Takebayashi 2022	5.8	1.32	81	2.28	1.36	36	3.52 [2.99, 4.05]	

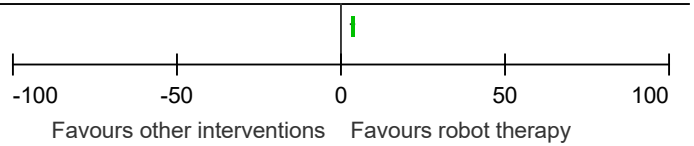


Figure 37: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final value) at end of intervention

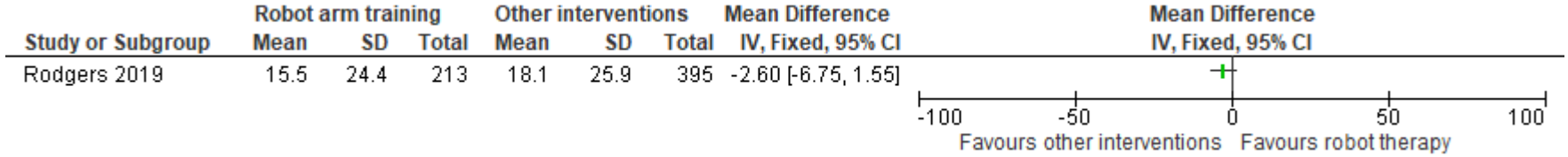


Figure 38: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, change score and final value) at ≥6 months

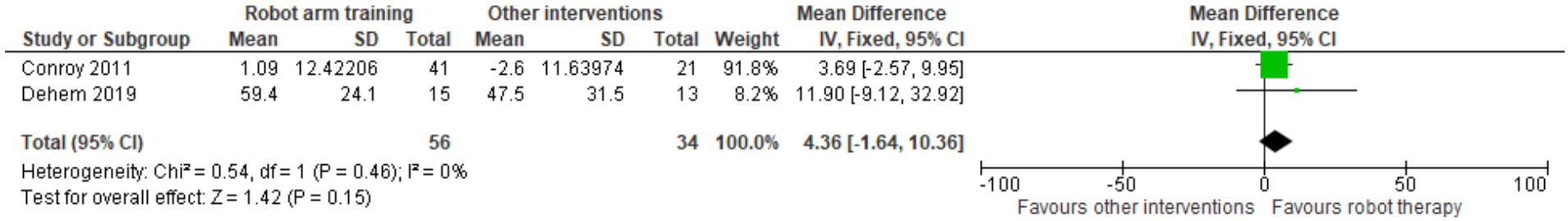


Figure 39: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final values and change scores) at ≥6 months

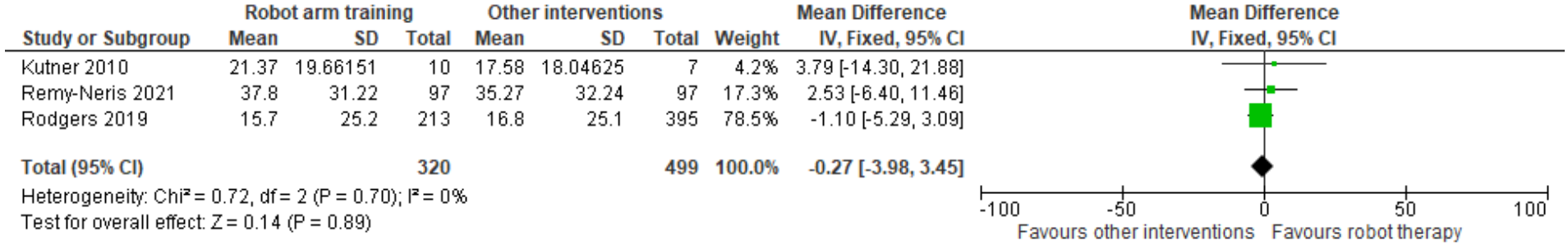


Figure 40: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, higher values are better, change score and final value) at ≥6 months

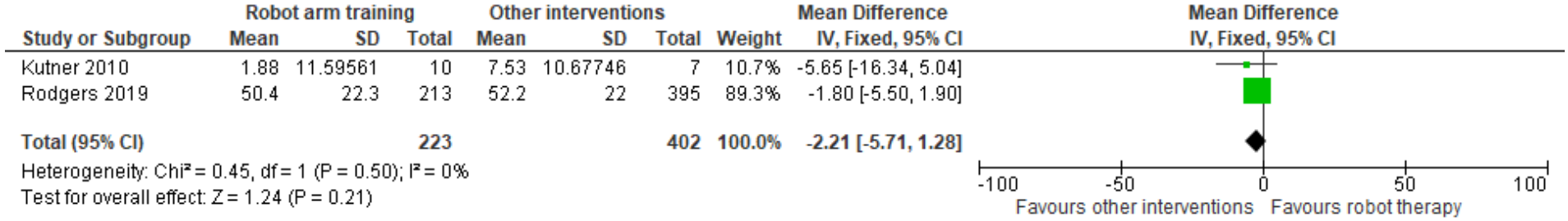


Figure 41: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, higher values are better, final value) at ≥6 months

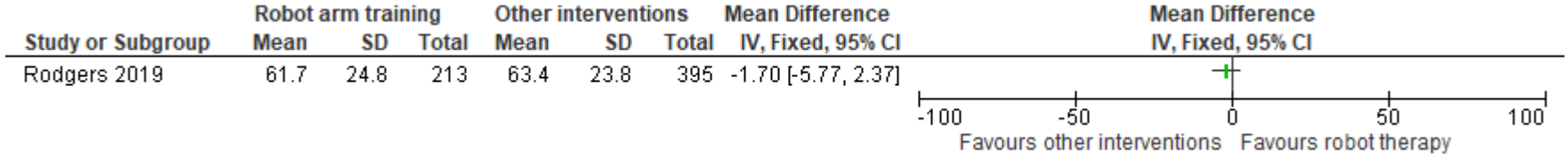


Figure 42: Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social participation domain, higher values are better, final value) at ≥6 months

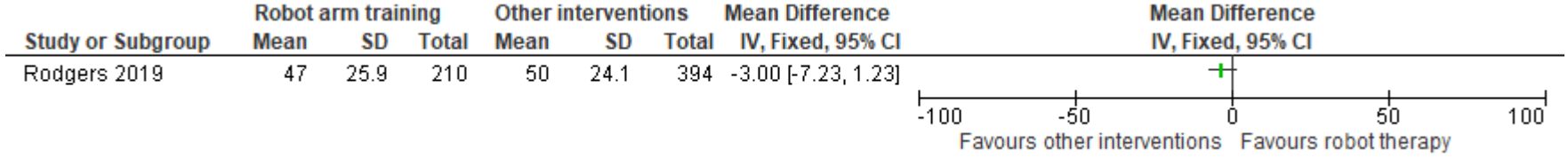


Figure 43: Withdrawal for any reason at end of intervention

Study or Subgroup	Robot arm training Events	Total	Other interventions Events	Total	Weight	Risk Difference M-H, Fixed, 95% CI
Abdollahi 2018	2	12	0	10	0.6%	0.17 [-0.08, 0.41]
Amirabdollahian 2007	0	16	0	15	0.8%	0.00 [-0.12, 0.12]
Ang 2014	1	15	0	7	0.5%	0.07 [-0.15, 0.29]
Aprile 2020	32	123	25	124	6.5%	0.06 [-0.05, 0.16]
Bishop 2014	2	16	1	15	0.8%	0.06 [-0.15, 0.26]
Brokaw 2014	0	7	2	5	0.3%	-0.40 [-0.83, 0.03]
Budhota 2021	0	22	0	22	1.2%	0.00 [-0.08, 0.08]
Burgar 2011	0	36	0	18	1.3%	0.00 [-0.08, 0.08]
Calabro 2019	0	25	0	25	1.3%	0.00 [-0.07, 0.07]
Carpinella 2020	1	20	1	20	1.1%	0.00 [-0.14, 0.14]
Chen 2021A	0	10	0	10	0.5%	0.00 [-0.17, 0.17]
Chen 2021B	0	10	0	10	0.5%	0.00 [-0.17, 0.17]
Chen 2022	2	16	5	15	0.8%	-0.21 [-0.50, 0.08]
Chinembiri 2021	10	25	0	25	1.3%	0.40 [0.20, 0.60]
Conroy 2011	5	41	2	21	1.5%	0.03 [-0.13, 0.19]
Coskunsu 2022	1	12	3	12	0.6%	-0.17 [-0.46, 0.12]
Daly 2005	1	7	0	6	0.3%	0.14 [-0.19, 0.47]
Dehem 2019	8	23	5	22	1.2%	0.12 [-0.14, 0.38]
Fazekas 2007	0	15	0	15	0.8%	0.00 [-0.12, 0.12]
Frisoli 2022	0	13	0	13	0.7%	0.00 [-0.14, 0.14]
Gandolfi 2019	0	16	0	16	0.8%	0.00 [-0.11, 0.11]
Grigoras 2016	0	13	0	12	0.7%	0.00 [-0.14, 0.14]
Gueye 2021	1	25	1	25	1.3%	0.00 [-0.11, 0.11]
Hesse 2005	1	22	0	22	1.2%	0.05 [-0.07, 0.16]
Hesse 2014	1	25	0	25	1.3%	0.04 [-0.06, 0.14]
Hollenstein 2011	0	7	0	6	0.3%	0.00 [-0.25, 0.25]
Housman 2009	2	17	1	17	0.9%	0.06 [-0.13, 0.25]
Hsieh 2011	0	12	0	6	0.4%	0.00 [-0.22, 0.22]
Hsieh 2014	0	32	0	16	1.1%	0.00 [-0.09, 0.09]
Hsu 2019	0	22	0	21	1.1%	0.00 [-0.09, 0.09]
Hsu 2021	0	17	2	17	0.9%	-0.12 [-0.29, 0.06]
Hung 2022	0	13	0	24	0.9%	0.00 [-0.11, 0.11]
Hwang 2012	0	9	0	8	0.4%	0.00 [-0.20, 0.20]
Kahn 2006	0	10	0	9	0.5%	0.00 [-0.18, 0.18]
Kim 2019	1	19	1	19	1.0%	0.00 [-0.14, 0.14]
Kim 2021	5	23	10	24	1.2%	-0.20 [-0.46, 0.06]
Kutner 2010	3	11	0	10	0.6%	0.27 [-0.01, 0.56]
Lee 2016	7	22	7	22	1.2%	0.00 [-0.28, 0.28]
Lee 2018	0	15	0	15	0.8%	0.00 [-0.12, 0.12]
Liao 2012	0	10	0	10	0.5%	0.00 [-0.17, 0.17]
Lin 2022	14	86	14	86	4.5%	0.00 [-0.11, 0.11]
Lo 2010	5	49	11	78	3.2%	-0.04 [-0.15, 0.08]
Lum 2002	2	15	1	15	0.8%	0.07 [-0.15, 0.28]
Lum 2006	0	24	0	6	0.5%	0.00 [-0.20, 0.20]
Ma 2022	3	13	4	13	0.7%	-0.08 [-0.42, 0.26]
Marganska 2014	1	39	3	38	2.0%	-0.05 [-0.15, 0.05]
Masiero 2007	2	17	3	18	0.9%	-0.05 [-0.28, 0.18]
Masiero 2011	0	11	0	10	0.6%	0.00 [-0.17, 0.17]
Mayr 2008	0	4	0	4	0.2%	0.00 [-0.37, 0.37]
McCabe 2015	0	12	0	27	0.9%	0.00 [-0.12, 0.12]
Orihuela-Espina 2016	0	9	0	9	0.5%	0.00 [-0.19, 0.19]
Park 2021	0	12	0	12	0.6%	0.00 [-0.15, 0.15]
Rabadi 2008	0	10	0	20	0.7%	0.00 [-0.14, 0.14]
Ranzani 2020	3	17	2	16	0.9%	0.05 [-0.19, 0.29]
Remy-Neris 2021	1	107	4	108	5.7%	-0.03 [-0.07, 0.01]
Rodgers 2019	18	257	44	513	18.0%	-0.02 [-0.06, 0.02]
Sale 2014	0	26	0	27	1.4%	0.00 [-0.07, 0.07]
Singh 2021	1	13	3	14	0.7%	-0.14 [-0.40, 0.12]
Straudi 2020	1	20	0	20	1.1%	0.05 [-0.08, 0.18]
Susanto 2015	0	9	1	10	0.5%	-0.10 [-0.34, 0.14]
Takahashi 2016	0	30	0	30	1.6%	0.00 [-0.06, 0.06]
Takebayashi 2022	8	87	6	42	3.0%	-0.05 [-0.17, 0.07]
Taravati 2021	5	22	3	23	1.2%	0.10 [-0.13, 0.32]
Taveggia 2016	0	27	0	27	1.4%	0.00 [-0.07, 0.07]
Timmermans 2014	0	11	0	11	0.6%	0.00 [-0.16, 0.16]
Tomic 2017	0	13	0	13	0.7%	0.00 [-0.14, 0.14]
Valles 2016	3	13	4	14	0.7%	-0.05 [-0.38, 0.27]
Vanoglio 2017	1	14	2	13	0.7%	-0.08 [-0.32, 0.16]
Villafane 2017	0	16	0	16	0.8%	0.00 [-0.11, 0.11]
Volpe 2000	0	30	0	26	1.5%	0.00 [-0.07, 0.07]
Wolf 2015	4	51	3	48	2.6%	0.02 [-0.08, 0.12]
Xu 2020	2	22	3	23	1.2%	-0.04 [-0.22, 0.14]
Total (95% CI)		**1890**		**2064**	**100.0%**	**-0.00 [-0.02, 0.02]**
Total events	160		177			

Heterogeneity: Chi² = 46.31, df = 71 (P = 0.99); I² = 0%

Test for overall effect: Z = 0.04 (P = 0.97)

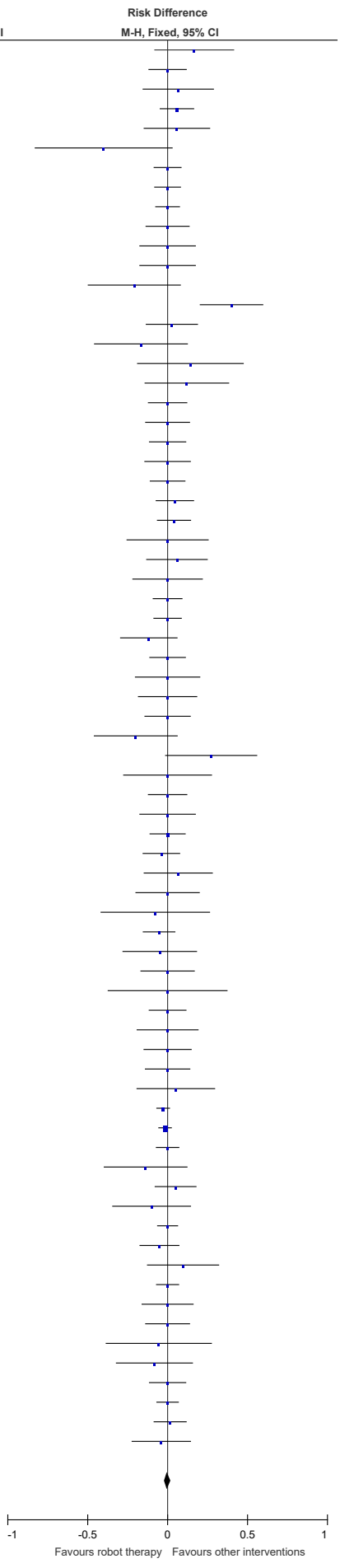


Figure 44: Withdrawal for any reason at ≥6 months

	Robot arm training		Other interventions			Risk Difference	Risk Difference
Study or Subgroup	**Events**	**Total**	**Events**	**Total**	**Weight**	**M-H, Fixed, 95% CI**	**M-H, Fixed, 95% CI**
Ang 2014	0	15	0	7	1.2%	0.00 [-0.19, 0.19]	
Budhota 2021	1	22	0	22	2.8%	0.05 [-0.07, 0.16]	
Burgar 2011	0	36	0	18	3.1%	0.00 [-0.08, 0.08]	
Conroy 2011	3	41	0	21	3.6%	0.07 [-0.03, 0.18]	
Dehem 2019	8	23	9	22	2.9%	-0.06 [-0.34, 0.22]	
Hesse 2014	2	25	2	25	3.2%	0.00 [-0.15, 0.15]	
Housman 2009	3	14	3	14	1.8%	0.00 [-0.30, 0.30]	
Hsu 2019	0	22	0	21	2.8%	0.00 [-0.09, 0.09]	
Hsu 2021	0	17	2	17	2.2%	-0.12 [-0.29, 0.06]	
Hung 2022	0	13	0	24	2.2%	0.00 [-0.11, 0.11]	
Kim 2019	1	19	1	19	2.4%	0.00 [-0.14, 0.14]	
Kutner 2010	0	11	0	10	1.3%	0.00 [-0.17, 0.17]	
Lum 2002	0	15	0	15	1.9%	0.00 [-0.12, 0.12]	
Lum 2006	6	24	1	6	1.2%	0.08 [-0.26, 0.43]	
Masiero 2011	0	11	0	10	1.3%	0.00 [-0.17, 0.17]	
Ranzani 2020	5	17	5	16	2.1%	-0.02 [-0.33, 0.30]	
Remy-Neris 2021	3	107	3	108	13.8%	0.00 [-0.04, 0.04]	
Rodgers 2019	11	257	38	513	44.0%	-0.03 [-0.06, 0.00]	
Susanto 2015	0	9	1	10	1.2%	-0.10 [-0.34, 0.14]	
Taveggia 2016	13	27	14	27	3.5%	-0.04 [-0.30, 0.23]	
Timmermans 2014	0	11	0	11	1.4%	0.00 [-0.16, 0.16]	
Total (95% CI)		**736**		**936**	**100.0%**	**-0.02 [-0.04, 0.01]**	
Total events	56		79				

Heterogeneity: Chi² = 8.02, df = 20 (P = 0.99); I² = 0%

Test for overall effect: Z = 1.24 (P = 0.21)

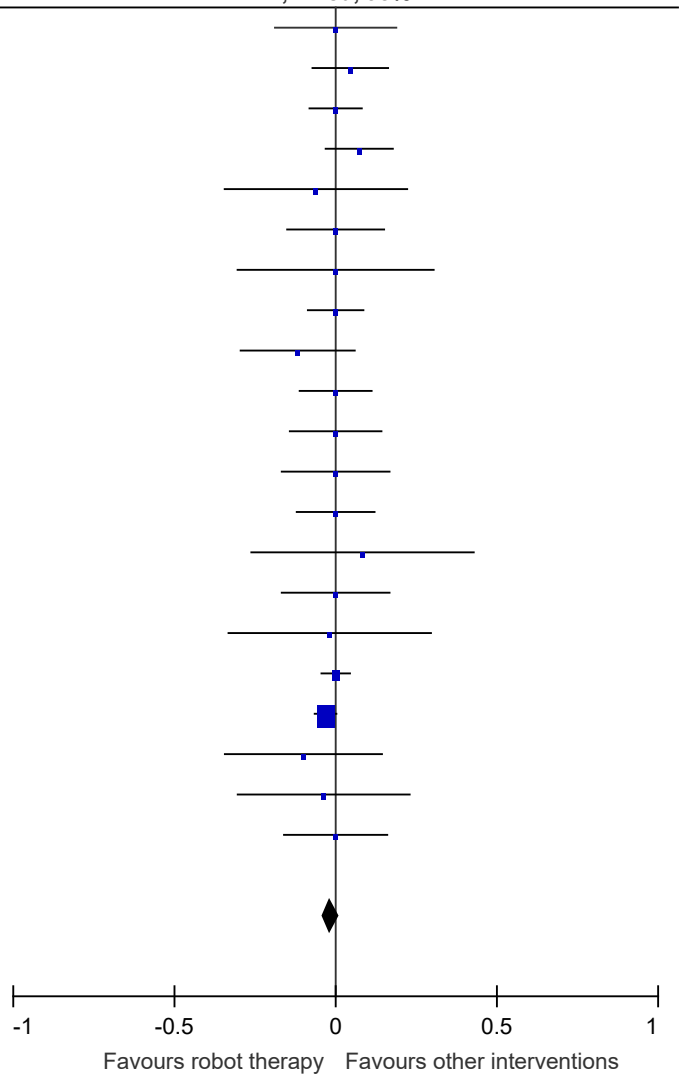


Figure 45: Adverse events (cardiovascular events) at end of intervention

Study or Subgroup	Robot arm training Events	Total	Other interventions Events	Total	Risk Ratio M-H, Fixed, 95% CI
Rodgers 2019	5	257	2	513	4.99 [0.97, 25.55]

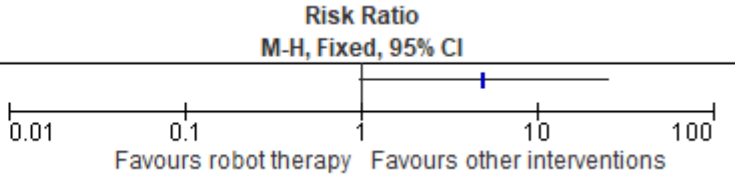


Figure 46: Adverse events (cardiovascular events) at ≥6 months

Study or Subgroup	Robot arm training Events	Total	Other interventions Events	Total	Risk Ratio M-H, Fixed, 95% CI
Rodgers 2019	2	257	2	513	2.00 [0.28, 14.09]

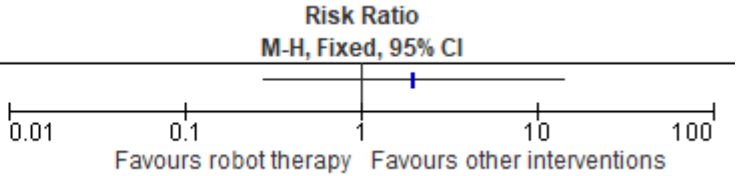


Figure 47: Adverse events (injuries and pain) at end of intervention

	Robot arm training		Other interventions			Risk Difference
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI
Hesse 2014	4	25	3	25	13.9%	0.04 [-0.15, 0.23]
Hsu 2021	0	17	0	17	22.1%	0.00 [-0.11, 0.11]
Lo 2010	12	49	9	78	18.6%	0.13 [-0.01, 0.27]
Remy-Neris 2021	45	107	59	108	19.3%	-0.13 [-0.26, 0.01]
Takebayashi 2022	8	87	0	42	26.1%	0.09 [0.02, 0.16]
Total (95% CI)		**285**		**270**	**100.0%**	**0.03 [-0.07, 0.13]**
Total events	69		71			

Heterogeneity: Tau² = 0.01; Chi² = 13.37, df = 4 (P = 0.010); I² = 70%

Test for overall effect: Z = 0.59 (P = 0.56)

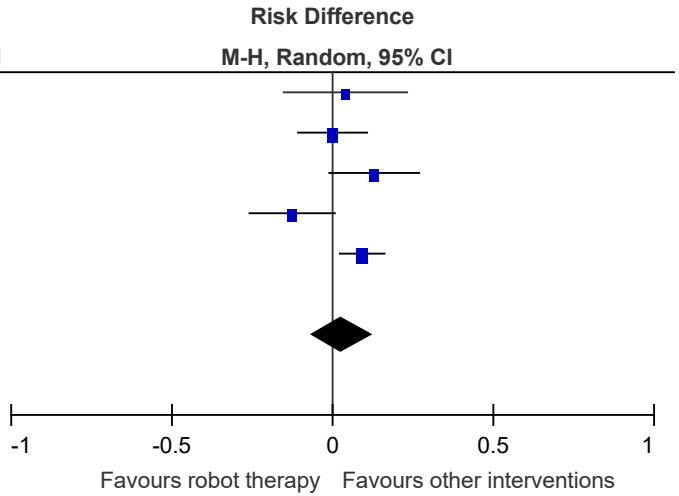


Figure 48: Adverse events (injuries and pain) at ≥6 months

	Robot arm training		Other interventions			Risk Difference
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% CI
Hesse 2014	0	25	0	25	16.7%	0.00 [-0.07, 0.07]
Hsu 2021	0	17	0	17	11.4%	0.00 [-0.11, 0.11]
Remy-Neris 2021	0	107	0	108	71.9%	0.00 [-0.02, 0.02]
Total (95% CI)		**149**		**150**	**100.0%**	**0.00 [-0.02, 0.02]**
Total events	0		0			

Heterogeneity: Chi² = 0.00, df = 2 (P = 1.00); I² = 0%

Test for overall effect: Z = 0.00 (P = 1.00)

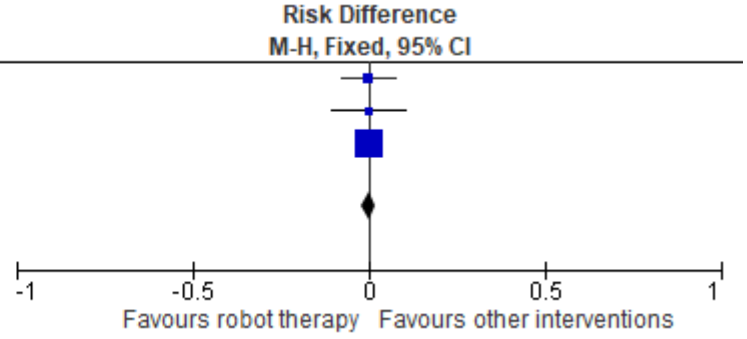


Figure 49: Adverse events (other reported adverse events) at end of intervention

Study or Subgroup	Robot arm training Events	Total	Other interventions Events	Total	Weight	Risk Difference M-H, Fixed, 95% CI
Ang 2014	1	15	0	7	1.2%	0.07 [-0.15, 0.29]
Budhota 2021	0	22	0	22	2.7%	0.00 [-0.08, 0.08]
Calabro 2019	0	25	0	25	3.0%	0.00 [-0.07, 0.07]
Chen 2021A	0	10	0	10	1.2%	0.00 [-0.17, 0.17]
Chen 2021B	2	10	1	10	1.2%	0.10 [-0.21, 0.41]
Chinembiri 2021	0	25	0	25	3.0%	0.00 [-0.07, 0.07]
Daly 2005	0	7	0	6	0.8%	0.00 [-0.25, 0.25]
Dehem 2019	2	23	1	22	2.7%	0.04 [-0.10, 0.19]
Fazekas 2007	0	15	0	15	1.8%	0.00 [-0.12, 0.12]
Hsu 2019	0	22	0	21	2.6%	0.00 [-0.09, 0.09]
Kim 2019	0	19	0	19	2.3%	0.00 [-0.10, 0.10]
Kim 2021	0	23	0	24	2.9%	0.00 [-0.08, 0.08]
Kutner 2010	0	11	0	10	1.3%	0.00 [-0.17, 0.17]
Lin 2022	1	86	1	86	10.4%	0.00 [-0.03, 0.03]
Remy-Neris 2021	4	107	5	108	13.0%	-0.01 [-0.06, 0.04]
Rodgers 2019	46	257	78	513	41.6%	0.03 [-0.03, 0.08]
Takahashi 2016	0	30	0	30	3.6%	0.00 [-0.06, 0.06]
Taveggia 2016	0	27	0	27	3.3%	0.00 [-0.07, 0.07]
Timmermans 2014	0	11	0	11	1.3%	0.00 [-0.16, 0.16]
Total (95% CI)		**745**		**991**	**100.0%**	**0.01 [-0.01, 0.04]**
Total events	56		86			

Heterogeneity: Chi² = 3.24, df = 18 (P = 1.00); I² = 0%

Test for overall effect: Z = 0.96 (P = 0.34)

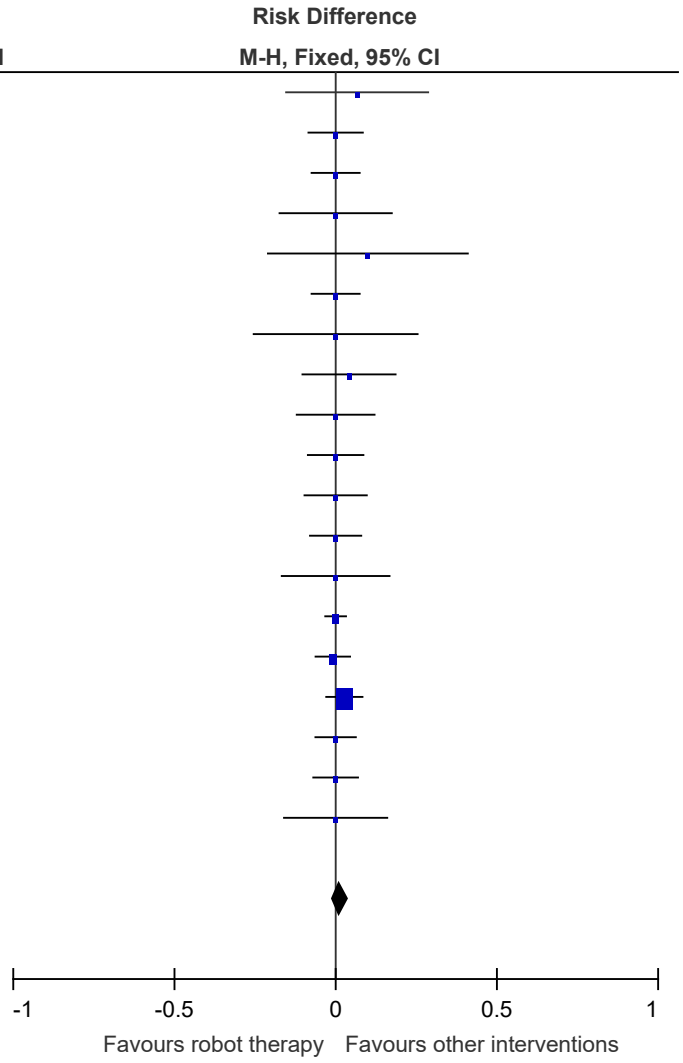
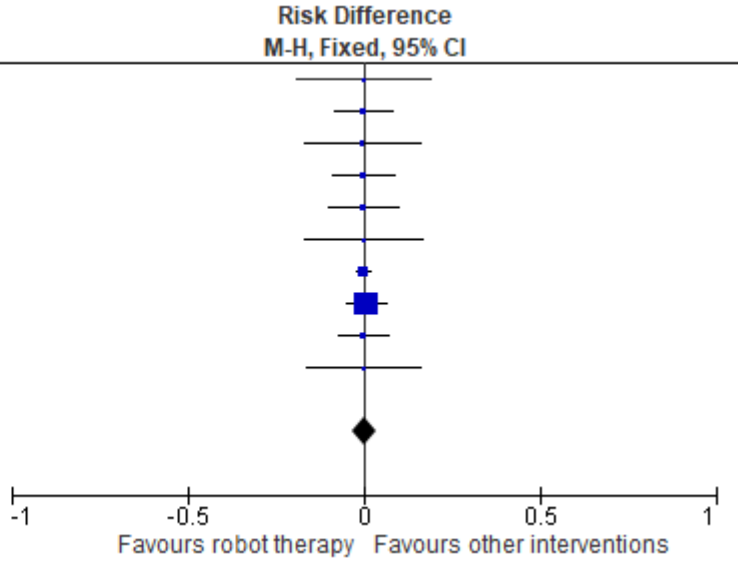


Figure 50: Adverse events (other reported adverse events) at ≥6 months

Study or Subgroup	Robot arm training Events	Total	Other interventions Events	Total	Weight	Risk Difference M-H, Fixed, 95% CI
Ang 2014	0	15	0	7	1.6%	0.00 [-0.19, 0.19]
Budhota 2021	0	22	0	22	3.7%	0.00 [-0.08, 0.08]
Dehem 2019	2	23	2	22	3.8%	-0.00 [-0.17, 0.16]
Hsu 2019	0	22	0	21	3.6%	0.00 [-0.09, 0.09]
Kim 2019	0	19	0	19	3.2%	0.00 [-0.10, 0.10]
Kutner 2010	0	11	0	10	1.8%	0.00 [-0.17, 0.17]
Remy-Neris 2021	0	107	0	108	18.1%	0.00 [-0.02, 0.02]
Rodgers 2019	44	257	84	513	57.8%	0.01 [-0.05, 0.06]
Taveggia 2016	0	27	0	27	4.6%	0.00 [-0.07, 0.07]
Timmermans 2014	0	11	0	11	1.9%	0.00 [-0.16, 0.16]
Total (95% CI)		**514**		**760**	**100.0%**	**0.00 [-0.03, 0.04]**
Total events	46		86			

Heterogeneity: Chi² = 0.27, df = 9 (P = 1.00); I² = 0%
Test for overall effect: Z = 0.24 (P = 0.81)



Appendix F – GRADE tables

Table 9: Clinical evidence profile: robot-assisted arm training compared to any other intervention

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Person/participant health related quality of life (SF-36 PCS, 0-100, higher values are better, change score) at end of intervention (follow-up: mean 5 weeks)												
2	randomised trials	very serious[a]	not serious	not serious	serious[b]	none	109	106	-	MD **0.73 higher** (0.81 lower to 2.27 higher)	⨁◯◯◯ Very low	CRITICAL
Person/participant health related quality of life (SF-36 MCS, 0-100, higher values are better, change score) at end of intervention (follow-up: mean 5 weeks)												
2	randomised trials	very serious[a]	not serious	not serious	serious[b]	none	109	106	-	MD **1.14 lower** (3.5 lower to 1.22 higher)	⨁◯◯◯ Very low	CRITICAL
Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final values and change scores) at end of intervention (follow-up: mean 4 weeks)												
2	randomised trials	very serious[c]	not serious	not serious	serious[b]	none	255	461	-	MD **0.01 higher** (0.02 lower to 0.03 higher)	⨁◯◯◯ Very low	CRITICAL
Person/participant health related quality of life (EQ5D, 0-100, higher values are better, change score) at ≥6 months (follow-up: 12 months)												
1	randomised trials	very serious[d]	not serious	not serious	serious[b]	none	97	97	-	MD **4.67 lower** (10.58 lower to 1.24 higher)	⨁◯◯◯ Very low	CRITICAL
Person/participant health related quality of life (EQ5D, -0.11-1, higher values are better, final values) at ≥6 months (follow-up: 6 months)												
1	randomised trials	serious[e]	not serious	not serious	serious[b]	none	221	404	-	MD **0.04 lower** (0.09 lower to 0.01 higher)	⨁⨁◯◯ Low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Activities of daily living (Barthel index, functional independence measure, stroke impact scale, MAL, Frenchay arm test, ABILHAND [different scale ranges], higher values are better, change scores) at end of intervention (follow-up: mean 5 weeks)												
25	randomised trials	very serious[a]	very serious[f]	not serious	serious[b]	none	678	640	-	SMD **0.41 SD higher** (0.16 higher to 0.67 higher)	⨁◯◯◯ Very low	CRITICAL
Activities of daily living (Barthel index, functional independence measure, Motor activity log [different scale ranges], higher values are better, final values) at end of intervention (follow-up: mean 5 weeks)												
11	randomised trials	not serious	not serious	not serious	not serious	none	389	599	-	SMD **0.14 SD higher** (0.01 higher to 0.27 higher)	⨁⨁⨁⨁ High	CRITICAL
Activities of daily living (Barthel index, functional independence measure, motor activity log [different scale ranges], higher values are better, change scores) at ≥6 months (follow-up: mean 6 months)												
9	randomised trials	not serious	serious[f]	not serious	serious[b]	none	247	222	-	SMD **0.28 SD higher** (0.09 higher to 0.46 higher)	⨁⨁◯◯ Low	CRITICAL
Activities of daily living (Barthel index, Functional Independence Measure [different scale ranges], higher values are better, final values) at ≥6 months (follow-up: mean 4 months)												
2	randomised trials	not serious	very serious[f]	not serious	not serious	none	244	426	-	SMD **0.02 SD higher** (0.14 lower to 0.17 higher)	⨁⨁◯◯ Low	CRITICAL
Arm function (FMA UE, Quick DASH, manual function test [different scale ranges], higher values are better, change scores) at end of intervention (follow-up: mean 5 weeks)												
48	randomised trials	serious[g]	serious[f]	not serious	not serious	none	1125	1042	-	SMD **0.34 SD higher** (0.26 higher to 0.43 higher)	⨁⨁◯◯ Low	CRITICAL
Arm function (FMA UE, Chedoke Arm and Hand Activity [different scale ranges], higher values are better, final values) at end of intervention (follow-up: mean 6 weeks)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
24	randomised trials	not serious	serious[f]	not serious	serious[b]	none	639	857	-	SMD **0.2 SD higher** (0.09 higher to 0.31 higher)	⨁⨁◯◯ Low	CRITICAL
Arm function (FMA UE, 0-66, higher values are better, change scores) at ≥6 months (follow-up: mean 6 months)												
11	randomised trials	serious[h]	not serious	not serious	not serious	none	288	229	-	MD **1.08 higher** (0.09 higher to 2.07 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Arm function (FMA UE, Korean DASH [different scale ranges], higher values are better, final values) at ≥6 months (follow-up: mean 4 months)												
9	randomised trials	serious[g]	very serious[f]	not serious	serious[b]	none	370	560	-	SMD **0.61 SD higher** (0.18 higher to 1.03 higher)	⨁◯◯◯ Very low	CRITICAL
Arm muscle strength (Motricity index, MRC, manual muscle test, MRC total motor power [different scale ranges], higher values are better, change scores) at end of intervention (follow-up: mean 5 weeks)												
21	randomised trials	very serious[a]	very serious[f]	not serious	serious[b]	none	548	471	-	SMD **0.45 SD higher** (0.17 higher to 0.72 higher)	⨁◯◯◯ Very low	CRITICAL
Arm muscle strength (Motricity index, MRC [different scale ranges], higher values are better, final values) at end of intervention (follow-up: mean 4 weeks)												
3	randomised trials	very serious[a]	serious[f]	not serious	serious[b]	none	57	50	-	SMD **0.89 SD higher** (0.19 higher to 1.6 higher)	⨁◯◯◯ Very low	CRITICAL
Arm muscle strength (grip strength [kg], higher values are better, change scores and final values) at end of intervention (follow-up: mean 5 weeks)												
5	randomised trials	not serious	not serious	not serious	serious[b]	none	63	60	-	MD **0.92 higher** (0.39 lower to 2.22 higher)	⨁⨁⨁◯ Moderate	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Arm muscle strength (grip strength [Newton meter], higher values are better, change score and final value) at end of intervention (follow-up: mean 6 weeks)												
2	randomised trials	not serious	not serious	not serious	not serious	none	56	58	-	MD **0.64 lower** (4.18 lower to 2.91 higher)	⨁⨁⨁⨁ High	CRITICAL
Arm muscle strength (MRC total, MRC total motor power [different scale ranges], higher values are better, change scores) at ≥6 months (follow-up: mean 5 months)												
4	randomised trials	serious[i]	very serious[f]	serious[i]	not serious	none	95	69	-	SMD **0.48 SD higher** (0.57 lower to 1.53 higher)	⨁◯◯◯ Very low	CRITICAL
Arm muscle strength (MRC total, MI [different scale ranges], higher values are better, final value) at ≥6 months (follow-up: mean 2 months)												
2	randomised trials	very serious[k]	not serious	serious[i]	not serious	none	42	42	-	SMD **1.05 SD higher** (0.59 higher to 1.51 higher)	⨁◯◯◯ Very low	CRITICAL
Arm muscle strength (grip strength [kg], higher values are better, change score and final value) at ≥6 months (follow-up: mean 6 months)												
2	randomised trials	not serious	not serious	not serious	serious[b]	none	35	36	-	MD **1.06 higher** (1.02 lower to 3.14 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at end of intervention (follow-up: mean 5 weeks)												
16	randomised trials	serious[i]	serious[f]	not serious	not serious	none	410	351	-	SMD **0.23 SD lower** (0.46 lower to 0.01 lower)	⨁⨁◯◯ Low	CRITICAL
Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at end of intervention (follow-up: mean 5 weeks)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
10	randomised trials	very serious[k]	not serious	not serious	not serious	none	168	188	-	SMD **0.21 SD lower** (0.42 lower to 0)	⨁⨁◯◯ Low	CRITICAL
Spasticity (MAS, MAS total [different scale ranges], lower values are better, change scores) at ≥6 months (follow-up: mean 5 months)												
7	randomised trials	serious[l]	not serious	serious[j]	not serious	none	137	110	-	SMD **0.09 SD lower** (0.34 lower to 0.17 higher)	⨁⨁◯◯ Low	CRITICAL
Spasticity (MAS, MAS total [different scale ranges], lower values are better, final values) at ≥6 months (follow-up: mean 3 months)												
4	randomised trials	very serious[k]	not serious	serious[j]	serious[b]	none	72	81	-	SMD **0.2 SD lower** (0.52 lower to 0.12 higher)	⨁◯◯◯ Very low	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, final values and change scores) at end of intervention (follow-up: mean 7 weeks)												
5	randomised trials	serious[l]	not serious	not serious	serious[b]	none	130	154	-	MD **5.31 higher** (2.6 higher to 8.02 higher)	⨁⨁◯◯ Low	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain [different scale ranges], higher values are better, change scores) at end of intervention (follow-up: mean 3 weeks)												
5	randomised trials	serious[g]	very serious[f]	not serious	serious[b]	none	218	164	-	SMD **0.8 SD higher** (0.31 lower to 1.91 higher)	⨁◯◯◯ Very low	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (SS-QOL, 49-245, higher values are better, final value) at end of intervention (follow-up: 4 weeks)												
1	randomised trials	very serious[m]	not serious	not serious	very serious[b]	none	17	20	-	MD **2.21 lower** (23.36 lower to 18.94 higher)	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - strength domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	not serious	none	81	36	-	MD **3.45 higher** (2.58 higher to 4.32 higher)	⨁⨁⨁⨁ High	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - memory domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	serious[b]	none	81	36	-	MD **0.19 higher** (0.52 lower to 0.9 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - emotion domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	serious[b]	none	81	36	-	MD **1.24 lower** (1.7 lower to 0.78 lower)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - communication domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	serious[b]	none	81	36	-	MD **0.32 lower** (0.94 lower to 0.3 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, 0-100, higher values are better, change scores and final value) at end of intervention (follow-up: mean 8 weeks)												
3	randomised trials	serious[n]	very serious[f]	not serious	not serious	none	304	438	-	MD **0.12 higher** (4.56 lower to 4.8 higher)	⨁◯◯◯ Very low	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, 0-100, higher values are better, change score and final value) at end of intervention (follow-up: mean 11 weeks)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
2	randomised trials	not serious	not serious	not serious	not serious	none	294	431	-	MD **0.44 higher** (3.91 lower to 4.79 higher)	⨁⨁⨁⨁ High	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social participation domain, 0-100, higher values are better, change score and final value) at end of intervention (follow-up: mean 11 weeks)												
2	randomised trials	not serious	not serious	not serious	serious[b]	none	291	430	-	MD **2.81 higher** (5.98 lower to 11.6 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - stroke recovery domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	serious[b]	none	81	36	-	MD **1.11 higher** (0.21 higher to 2.01 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - physical domain, 0-100, higher values are better, change score) at end of intervention (follow-up: 10 weeks)												
1	randomised trials	not serious	not serious	not serious	not serious	none	81	36	-	MD **3.52 higher** (2.99 higher to 4.05 higher)	⨁⨁⨁⨁ High	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final value) at end of intervention (follow-up: mean 12 weeks)												
1	randomised trials	serious[o]	not serious	not serious	not serious	none	213	395	-	MD **2.6 lower** (6.75 lower to 1.55 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale total, 0-100, higher values are better, change score and final value) at ≥6 months (follow-up: mean 5 months)												
2	randomised trials	serious[p]	not serious	serious[i]	not serious	none	56	34	-	MD **4.36 higher** (1.64 lower to 10.36 higher)	⨁⨁◯◯ Low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - hand function domain, 0-100, higher values are better, final values and change scores) at ≥6 months (follow-up: mean 7 months)												
3	randomised trials	serious[n]	not serious	not serious	not serious	none	320	499	-	MD **0.27 lower** (3.98 lower to 3.45 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - ADL domain, higher values are better, change score and final value) at ≥6 months (follow-up: mean 4 months)												
2	randomised trials	serious[n]	not serious	not serious	not serious	none	223	402	-	MD **2.21 lower** (5.71 lower to 1.28 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - mobility domain, higher values are better, final value) at ≥6 months (follow-up: 6 months)												
1	randomised trials	serious[o]	not serious	not serious	not serious	none	213	395	-	MD **1.7 lower** (5.77 lower to 2.37 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Stroke-specific Patient-Reported Outcome Measures (Stroke Impact Scale - social participation domain, higher values are better, final value) at ≥6 months (follow-up: 6 months)												
1	randomised trials	serious[o]	not serious	not serious	not serious	none	210	394	-	MD **3 lower** (7.23 lower to 1.23 higher)	⨁⨁⨁◯ Moderate	CRITICAL
Withdrawal for any reason at end of intervention (follow-up: mean 6 weeks)												
72	randomised trials	not serious	serious[q]	not serious	very serious[r]	none	160/1890 (8.5%)	177/2064 (8.6%)	**RD 0.00** (-0.02 to 0.02)	**0 fewer per 1,000** (from 20 fewer to 20 more)[s]	⨁◯◯◯ Very low	CRITICAL
Withdrawal for any reason at ≥6 months (follow-up: mean 6 months)												
21	randomised trials	not serious	serious[q]	not serious	very serious[r]	none	56/736 (7.6%)	79/936 (8.4%)	**RD -0.02** (-0.04 to 0.01)	**20 fewer per 1,000** (from 40 fewer to 10 more)[s]	⨁◯◯◯ Very low	CRITICAL

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
Adverse events (cardiovascular events) at end of intervention (follow-up: 3 months)												
1	randomised trials	not serious	not serious	not serious	very serious[b]	none	5/257 (1.9%)	2/513 (0.4%)	**RR 4.99** (0.97 to 25.55)	**16 more per 1,000** (from 0 fewer to 96 more)	⨁⨁◯◯ Low	CRITICAL
Adverse events (cardiovascular events) at ≥6 months (follow-up: 6 months)												
1	randomised trials	not serious	not serious	not serious	very serious[b]	none	2/257 (0.8%)	2/513 (0.4%)	**RR 2.00** (0.28 to 14.09)	**4 more per 1,000** (from 3 fewer to 51 more)	⨁⨁◯◯ Low	CRITICAL
Adverse events (injuries and pain) at end of intervention (follow-up: mean 7 weeks)												
5	randomised trials	not serious	serious[q]	not serious	very serious[r]	none	69/285 (24.2%)	71/270 (26.3%)	**RD 0.03** (-0.07 to 0.13)	**30 more per 1,000** (from 70 fewer to 130 more)[s]	⨁◯◯◯ Very low	CRITICAL
Adverse events (injuries and pain) at ≥6 months (follow-up: mean 6 months)												
3	randomised trials	not serious	not serious	not serious	not serious	none	0/149 (0.0%)	0/150 (0.0%)	**RD 0.00** (-0.02 to 0.02)	**0 fewer per 1,000** (from 20 fewer to 20 more)[s]	⨁⨁⨁⨁ High	CRITICAL
Adverse events (other reported adverse events) at end of intervention (follow-up: mean 6 weeks)												
19	randomised trials	not serious	serious[q]	not serious	very serious[r]	none	56/745 (7.5%)	86/991 (8.7%)	**RD 0.01** (-0.01 to 0.04)	**10 more per 1,000** (from 10 fewer to 40 more)[s]	⨁◯◯◯ Very low	CRITICAL
Adverse events (other reported adverse events) at ≥6 months (follow-up: mean 5 months)												

Certainty assessment							№ of patients		Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations	robot-assisted arm training	all other interventions	Relative (95% CI)	Absolute (95% CI)		
10	randomised trials	not serious	serious[q]	not serious	very serious[r]	none	46/514 (8.9%)	86/760 (11.3%)	**RD 0.00** (-0.03 to 0.04)	**0 fewer per 1,000** (from 30 fewer to 40 more)[s]	⨁◯◯◯ Very low	CRITICAL

CI: confidence interval; **MD:** mean difference; **RR:** risk ratio; **SMD:** standardised mean difference

Explanations

a. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias arising from the randomisation process, bias due to deviation from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome)

b. Downgraded by 1 increment if the confidence interval crossed one MID or by 2 increments if the confidence interval crossed both MIDs

c. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias in the randomisation process, bias due to missing outcome data and bias in measurement of the reported result)

d. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias in measurement of the outcome and bias in selection of the reported result)

e. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to bias in measurement of the outcome)

f. Downgraded by 1 or 2 increments because heterogeneity, unexplained by subgroup analysis

g. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data, bias in measurement of the outcome and bias in selection of the reported result)

h. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention and bias due to missing outcome data)

i. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome)

j. Downgraded by 1 increments due to outcome indirectness (as the majority of evidence was reported at a follow up of less than 6 months)

k. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias arising from the randomisation process, bias due to deviation from the intended intervention, bias due to missing outcome data, bias in measurement of the outcome and bias in selection of the reported result)

l. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention, bias due to missing outcome data and bias in measurement of the outcome)

m. Downgraded by 2 increments as the majority of the evidence was of very high risk of bias (due to bias due to deviation from the intended intervention and bias due to missing outcome data)

n. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process and bias in measurement of the outcome)

o. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to bias in measurement of the outcome)

p. Downgraded by 1 increment as the majority of the evidence was of high risk of bias (due to a mixture of bias arising from the randomisation process, bias due to deviations from the intended intervention and bias due to missing outcome data)

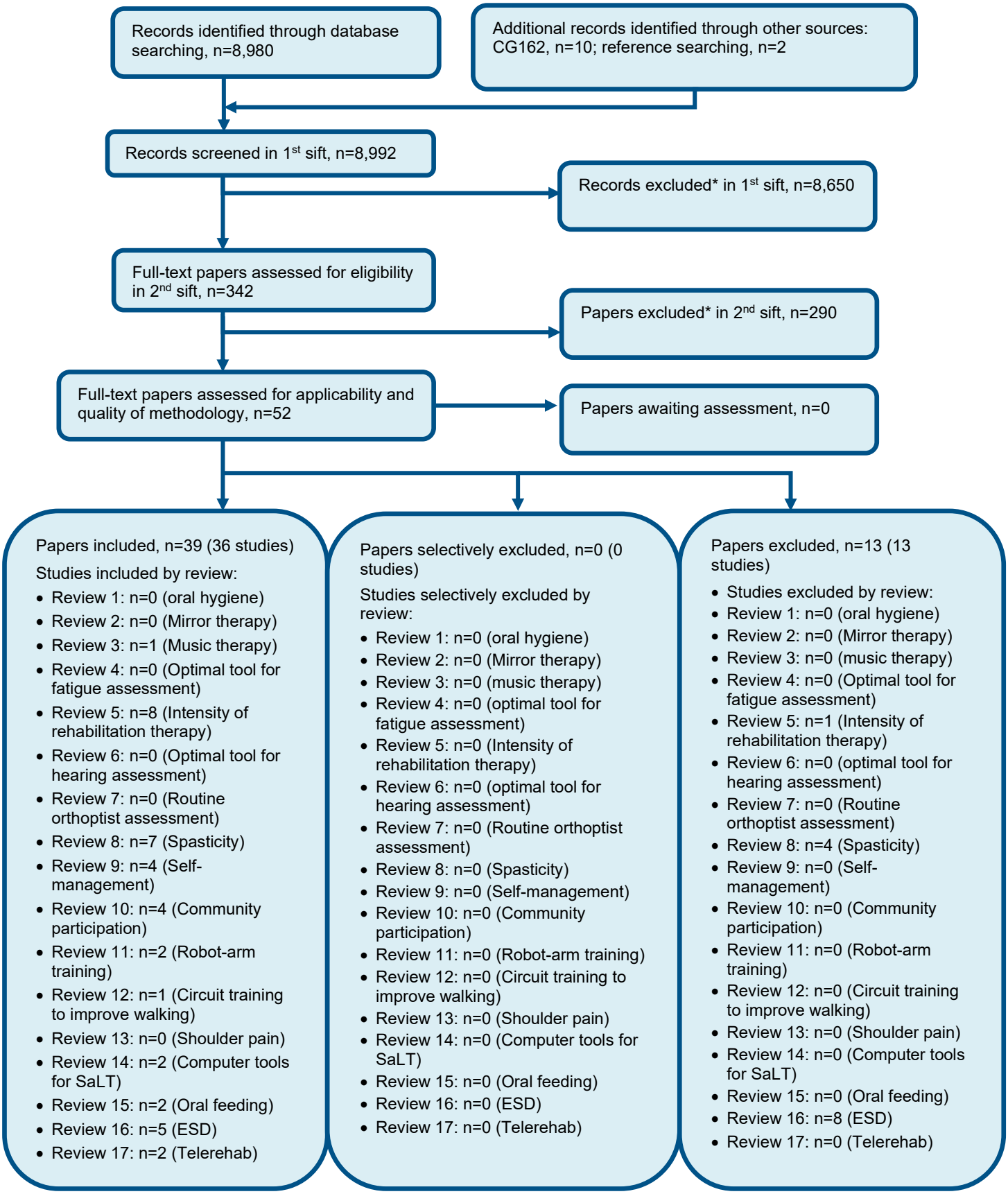
q. Downgraded for heterogeneity due to conflicting number of events in different studies (zero events in one or more studies)

r. Downgraded by 1 to 2 increments for imprecision due to zero events and small sample size

s. Absolute effect calculated by risk difference due to zero events in at least one arm of one study

Appendix G – Economic evidence study selection

Figure 1: Flow chart of health economic study selection for the guideline



* Non-relevant population, intervention, comparison, design or setting; non-English language

Appendix H – Economic evidence tables

Study	Fernandez-Garcia 2021[32]			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: Cost-utility analysis (CUA) (health outcome: QALYs) **Study design:** Within-trial analysis (RCT- RATULS[88]) In a sensitivity analysis modelling was used to extrapolate results beyond trial follow-up. **Approach to analysis:** Analysis of individual level healthcare resource use and EQ-5D to estimate costs and QALYs over 6 months follow-up. Unit costs applied. Adjusted differences between groups were calculated using regression analysis incorporating randomised group, study centre, time since stroke, baseline utility	**Population:** Adults with moderate or severe upper limb functional limitation (Action Research Arm Test [ARAT] score 0–39) as a result of first-ever stroke that had occurred between 1 week and 5 years before randomisation. The median time from stroke to randomisation was 240 days (IQR 109–549 days), and participants had a mean ARAT score of 8.4 points (SD 11.8 points). A total of 409 out of 768 (53.3%) participants were receiving physiotherapy and/or occupational therapy at the time of randomisation. **Patient characteristics:** N = 768 Mean age = 61 years (SD 13.5 years) Male= 60.8%	**Total costs (mean per patient):** Intervention 1: £3785 (98.33% CI £2801 to £4770) Intervention 2: £5387 (98.33% CI £4777 to £5996) Intervention 3: £4451 (98.33% CI £3548 to £5354) **Incremental:** **2-1 (unadjusted as adjusted not reported):** £1601 (95% CI £706 to £2496) **3-1(adjusted):** £741 (98.33 CI –£461 to £1943) **3-2 (adjusted):** £741 (98.33 CI –£461 to £1943) **Currency & cost year:** 2018 UK pounds (£)	**QALYs (mean per patient):** Intervention 1: 0.21 (98.33% CI 0.19 to 0.23) Intervention 2: 0.21 (98.33% CI 0.19 to 0.23) Intervention 3: 0.23 (98.33% CI 0.21 to 0.24) **Incremental:** **2-1 (unadjusted):** 0.00 (95% CI -0.20 to 0.20) **3−1 (unadjusted):** 0.010 (98.33% CI -0.005 to 0.025) Note that adjusted QALY outcomes for each group were not reported, however authors reported that adjusted QALYs were lower.	**ICERs** Intervention 2 was dominated by intervention 3 due to higher costs and lower QALYs. Intervention 3 versus Intervention 1: £74,100 per QALY gained CI: NR Probability cost effective (£20K threshold): intervention 1 81%; intervention 2 0%; intervention 3 19%. **Analysis of uncertainty:** Scenario 1 examined the impact of assigning a value of zero to missing total healthcare costs, resulting in the ICER between EULT and usual care increasing to £172,000. Scenario 2 examined the possibility that those participants with missing total healthcare costs may have used some services and hence incurred some costs. This decreased the ICER between EULT and usual care to £50,000 with the probability of EULT being cost-effective at a £20,000 WTP threshold increasing to 27%.

(QALY analysis only) and baseline costs (cost analysis only) as explanatory variables. **Perspective:** UK NHS and PSS **Follow-up:** 6 months **Treatment effect duration:**[(a)] 6 months **Discounting:** NA	**Intervention 1:** Usual care (45 minutes with a physiotherapist or occupational therapist, 5 days a week) over 12 weeks. **Intervention 2:** Robot-assisted training (45 minutes per day, 3 times per week) plus usual care over 12 weeks. **Intervention 3:** Enhanced upper limb therapy (EULT) (45 minutes with a physiotherapist, 3 times per week) plus usual care over 12 weeks.	**Cost components incorporated:** Intervention costs, follow-up costs, primary care, therapy and community-based, services, secondary care, residential and nursing home care, social services, medication costs.		Scenario 3 increased the life span of the MIT-Manus robotic gym system from 5 to 7 years. This resulted in a reduction of the mean capital costs per patient and hence, in a lower mean total cost for the robot-assisted training group (£5085) compared with the base-case analysis (£5387). Robot-assisted training remained dominated by EULT and did not change the ICER from the base case results (£74,100). A secondary per-protocol within-trial cost-effectiveness analysis removed from the data set those participants who did not receive at least 20 sessions of therapy in the robot-assisted training and the EULT programme groups was also conducted. Usual care remained the least costly option, followed by EULT and robot-assisted training. The ICER between usual care and EULT was £68,000 and the probability of usual care being cost-effective at a £20,000 WTP threshold increased to 92%. Extrapolation of trial data on costs and effects to 12 months: The ICER for the comparison between EULT and usual care was £6,095, however there was only a 55% probability of EULT being considered cost-effective compared with usual care at the £20,000 WTP value. Robot-assisted training had no probability of being cost-effective at this WTP value.

Data sources
Health outcomes: Within-trial analysis of RATULS trial[88] included in the clinical review. EQ-5D collected at baseline and at 3- and 6-months post-randomisation was used to calculate QALYs using the area under the curve method. **Quality-of-life weights:** Within-RCT analysis: EQ-5D-5L mapped to EQ-5D-3L, UK population valuation tariff. **Cost sources:** Resource use from within RCT. UK national unit costs applied.
Comments
Source of funding: National Institute for Health Research Health Technology Assessment Programme. **Limitations:** Within-trial analysis based on RATULS RCT and so only reflects this study and not the wider evidence base identified in the clinical review. **Other:** This study, as well as the RCT[88] that formed the basis of the analysis are also included as part of the evidence review for this guideline that assessed the clinical and cost-effectiveness of more intensive rehabilitation.
Overall applicability:[(b)] Directly applicable **Overall quality:**[(c)] Minor limitations

Abbreviations: SD = standard deviation; NR = not reported; ARAT = Action Research Arm Test; QALY=quality-adjusted life year; EULT = Enhanced upper limb therapy; IQR = Interquartile range.

a) *For studies where the time horizon is longer than the treatment duration, an assumption needs to be made about the continuation of the study effect. For example, does a difference in utility between groups during treatment continue beyond the end of treatment and if so for how long.*
b) *Directly applicable / Partially applicable / Not applicable*
c) *Minor limitations / Potentially serious Limitations / Very serious limitations*

Study	Remy-Neris 2021[50]			
Study details	**Population & interventions**	**Costs**	**Health outcomes**	**Cost effectiveness**
Economic analysis: Cost-utility analysis (health outcome: QALYs) **Study design:** Within-trial analysis of an RCT (n=215) included in the clinical review (same paper) with no modelled extrapolation.	**Population:** Adults, 3 weeks to 3 months post-stroke, with a Fugl-Meyer Assessment (FMA) score of 10 to 40 points. **Patient characteristics:** Mean age (SD): 58 (13.63) years old Male: 65%	**Total costs (mean per patient):** Intervention 1: £45,843 (95% CI: £42,113 to £49,393; p=NR) Intervention 2: £45,744 (95% CI: £42,195 to £49,293; p=NR) Incremental (2−1): Saves £99 (95% CI: NR; p=0.99)	**QALYs (mean per patient (SD)):**[(c)] Intervention 1: 0.47 (0.26) Intervention 2: 0.48 (0.25) Incremental (2−1): 0.01 (95% CI: NR; p=0.87)	**ICER (Intervention 2 versus Intervention 1):** NR. Results suggested that the Exo group intervention dominates usual care (lower costs and higher QALYs), however total costs and QALY gains were not statistically significant between groups. Probability Intervention 2 cost effective (£20K/30K threshold): NR/NR **Analysis of uncertainty:**

Approach to analysis: Analysis of individual level healthcare resource use and EQ-5D to estimate costs and QALYs associated with self-rehabilitation (using a mechanized device) on post-stroke upper extremity impairment compared to those receiving control self-exercises. Unit costs applied. **Perspective:** French Health system **Follow-up:** 1 year **Treatment effect duration:**[(a)] 1 year **Discounting:** NA	**Intervention 1:** Control group (n=108) was provided with usual rehabilitation for 1 hour, 5 days per week plus an additional daily hour of self-rehabilitation (two 30-minute sessions) consisting of basic stretching and active exercises for 4 weeks. **Intervention 2:** The Exo group (n=107) was provided with usual rehabilitation for 1 hour, 5 days per week plus an additional daily hour of self-rehabilitation (two 30-minute sessions) consisting of gravity-supported, games-based training using an exoskeleton (Armeo®Spring) for 4 weeks.	**Currency & cost year:** 2018 euros converted to UK pounds (£)[(b)] **Cost components incorporated:** ArmeoSpring exoskeleton (device cost, 5-year linear depreciation, maintenance, and physical therapist for patient training). Resource use estimates included inpatient rehabilitation days, outpatient physiotherapy, GP and specialist consultations and transportation costs.		Results were robust to probabilistic sensitivity analysis, were uncertainty on the ICER was described using 1000 bootstrap replications on the cost-effectiveness plane.
Data sources				
Health outcomes: Within-trial analysis of a single-blind phase III RCT (same paper) included in the clinical review, where the primary outcome was the change in upper extremity impairment, measured using FMA UE scores collected at baseline and 4 weeks. Health-related quality of life was assessed using the EQ-5D-3L questionnaire at baseline and 1 year. Other secondary outcomes included FIM and SIS hand function. **Quality-of-life weights:** Within-trial analysis using EQ-5D-3L with French preference weights applied. **Cost sources:** References for cost sources were not reported, however the authors stated that data from both hospital and non-hospital resources were collected prospectively in the study case report form and patients' diaries. Hospitalisation costs were estimated from the average national severity-related group cost and average length of stay in rehabilitation per patient group. Repeated admissions during the 12 months after the initial intervention were also included in the cost computations using the same methodology.				
Comments				

Source of funding: The French Ministry of Health. **Limitations:** French healthcare system may not reflect current UK NHS context. French population valuation tariff was used to estimate QALYs but NICE reference case specifies that the UK tariff is preferred. Within-trial analysis based on a single-blind RCT, therefore results only reflect this study and not the wider evidence base identified in the clinical review. References for unit costs were not reported which limits interpretation of results for UK context. **Other:** None.

Overall applicability:[d] Partially applicable **Overall quality:**[e] Potentially serious limitations

Abbreviations: 95% CI= 95% confidence interval; EQ-5D-3L= EuroQol-5 Dimensions, three-level version (scale: 0.0 [death] to 1.0 [full health], negative values mean worse than death); FIM= functional independence measure (scale 0-18, higher values are better); FMA UE= Fugl-Meyer Assessment Upper Extremity (scale 0-66, higher scores are better); ICER= incremental cost-effectiveness ratio; NA= not applicable; NR= not reported; QALYs= quality-adjusted life years; RCT= randomised controlled trial; SIS hand function= stroke Impact Scale - hand function domain (scale 0-100, higher values are better).

a) For studies where the time horizon is longer than the treatment duration, an assumption needs to be made about the continuation of the study effect. For example, does a difference in utility between groups during treatment continue beyond the end of treatment and if so for how long.

b) Converted using 2018 purchasing power parities.[81] References for unit costs were not reported but 2018 was assumed based on the study completion date.

c) Mean difference taken from Figure 4 of guideline clinical review.

d) Directly applicable / Partially applicable / Not applicable

e) Minor limitations / Potentially serious limitations / Very serious limitations

Appendix I – Health economic model

Health economic modelling was not undertaken for this review.

Appendix J – Excluded studies

Clinical studies

Table 10: Studies excluded from the clinical review

Study	Code [Reason]
(2020) Correction...McCabe J, Monkiewicz M, Holcomb J, et al. Comparison of Robotics, Functional Electrical Stimulation, and Motor Learning Methods for Treatment of Persistent Upper Extremity Dysfunction After Stroke: A Randomized Controlled Trial. Archives of Physical Medicine and Rehabilitation. 2015;96(6):981-990. Archives of Physical Medicine & Rehabilitation 101(4): 730-730	- Correction only
(2019) Does emg-driven robotic treatment have effect for the recovery of the hand 9 years after stroke?. Gait & Posture 73: 362-363	- Full text paper not available
Adamovich, S. V. (2018) Robot assisted virtual rehabilitation for the hand post stroke (RAVR).	- Full text paper not available
Adomaviciene, A., Daunoraviciene, K., Kubilius, R. et al. (2019) Influence of New Technologies on Post-Stroke Rehabilitation: A Comparison of Armeo Spring to the Kinect System. Medicina 55(4): 09	- Comparator in study does not match that specified in this review protocol
Aguiar, L. T., Nadeau, S., Martins, J. C. et al. (2020) Efficacy of interventions aimed at improving physical activity in individuals with stroke: a systematic review. Disability & Rehabilitation 42(7): 902-917	- Systematic review used as source of primary studies
Akcay, S, Karagozoglu, Coskunsu D, Erkan, Ogul O et al. (2020) The effect of robotic rehabilitation for recovery of hand functions in patients with acute stroke: Pilot study. Gait and Posture 81(s1): 6-7.	- Conference abstract
Ambrosini, E., Gasperini, G., Zajc, J. et al. (2021) A Robotic System with EMG-Triggered Functional Eletrical Stimulation for Restoring Arm Functions in Stroke Survivors. Neurorehabilitation & Neural Repair 35(4): 334-345	- Study does not contain an intervention relevant to this review protocol
Anonymous (2020) Correction: Comparison of Robotics, Functional Electrical Stimulation, and Motor Learning Methods for Treatment of Persistent Upper Extremity Dysfunction After	- Correction only

Study	Code [Reason]
Stroke: A Randomized Controlled Trial (Archives of Physical Medicine and Rehabilitation (2015) 96(6) (981-990), (S0003999314012283), (10.1016/j.apmr.2014.10.022)). Archives of Physical Medicine and Rehabilitation 101(4): 730	
Arya, K. N.; Pandian, S.; Puri, V. (2018) Rehabilitation methods for reducing shoulder subluxation in post-stroke hemiparesis: a systematic review. Topics in Stroke Rehabilitation 25(1): 68-81	- Systematic review used as source of primary studies
Bajaj, P. and Contractor, A. (2022) EFFICACY OF UPPER EXTREMITY ROBOTIC REHABILITATION IN ADDITION TO CONVENTIONAL REHABILITATION IN FUNCTIONAL IMPROVEMENT IN CHRONIC STROKE IN A TERTIARY CARE HOSPITAL IN INDIA. International Journal of Stroke 17(3supplement): 127	- Conference abstract
Baniqued, P. D. E., Stanyer, E. C., Awais, M. et al. (2021) Brain-computer interface robotics for hand rehabilitation after stroke: a systematic review. Journal of Neuroengineering & Rehabilitation 18(1): 15	- Systematic review used as source of primary studies
Bayindir, O; Akyuz, G; Sekban, N (2022) The effect of adding robot-assisted hand rehabilitation to conventional rehabilitation program following stroke: a randomized-controlled study. Turkish journal of physical medicine and rehabilitation 68(2): 254-261	- Data not reported in an extractable format or a format that can be analysed *Medians and interquartile ranges*
Bernhardt, J and Mehrholz, J (2019) Robotic-assisted training after stroke: RATULS advances science. Lancet 394(10192): 6-8.	- Conference abstract
Bressi, F., Bravi, M., Campagnola, B. et al. (2020) Robotic treatment of the upper limb in chronic stroke and cerebral neuroplasticity: a systematic review. Journal of Biological Regulators & Homeostatic Agents 34(5suppl3): 11-44. Technology in Medicine	- Systematic review used as source of primary studies
Bumin, G.; Colak, F.D.; Yasar, E. (2022) THE EFFECT OF UPPER EXTREMITY ROBOTIC REHABILITATION ON ACTIVITY PERFORMANCE IN INDIVIDUALS WITH STROKE. International Journal of Stroke 17(3supplement): 252-253	- Conference abstract

Study	Code [Reason]
Burridge, Jane and Hughes, Ann-Marie (2020) Robot-assisted training offers little improvement in severe arm weakness and functions after stroke. Frontline (20454910) 26(1): 42-43	- Conference abstract
Cantillo-Negrete, J., Carino-Escobar, R. I., Carrillo-Mora, P. et al. (2021) Brain-Computer Interface Coupled to a Robotic Hand Orthosis for Stroke Patients' Neurorehabilitation: A Crossover Feasibility Study. Frontiers in Human Neuroscience 15 (no pagination)	- Study design not relevant to this review protocol
Carpinella, I, Lencioni, T, Bowman, T et al. (2019) Planar robotic training versus arm-specific physiotherapy: effects on arm function and motor strategies in post-stroke subjects. Gait and Posture 74(s): 7	- Full text paper not available
Cecchi, F., Germanotta, M., Macchi, C. et al. (2021) Age is negatively associated with upper limb recovery after conventional but not robotic rehabilitation in patients with stroke: a secondary analysis of a randomized-controlled trial. Journal of Neurology 268(2): 474-483	- Secondary publication of an included study that does not provide any additional relevant information
Chen, Z., Wang, C., Fan, W. et al. (2020) Robot-Assisted Arm Training versus Therapist-Mediated Training after Stroke: A Systematic Review and Meta-Analysis. Journal of Healthcare Engineering 2020: 8810867	- Systematic review used as source of primary studies
Chen, Z., Xia, N., He, C. et al. (2021) Action observation treatment-based exoskeleton (AOT-EXO) for upper extremity after stroke: study protocol for a randomized controlled trial. Trials [Electronic Resource] 22(1): 222	- Study design not relevant to this review protocol
Chien, W. T., Chong, Y. Y., Tse, M. K. et al. (2020) Robot-assisted therapy for upper-limb rehabilitation in subacute stroke patients: A systematic review and meta-analysis. Brain and Behavior 10(8): e01742	- Systematic review used as source of primary studies
Chinembiri, B. (2019) Comparing the effects of Fourier M2 robotic rehabilitation machine combined with conventional occupational therapy on hand function and quality of life in patients whose arms have been affected by a recent first stroke.	- Full text paper not available

Study	Code [Reason]
Chua, K., Kuah, C., Ng, C. et al. (2018) Clinical and kinematic evaluation of the H-Man arm robot for post-stroke upper limb rehabilitation: preliminary findings of a randomised controlled trial. Annals of physical and rehabilitation medicine	- Full text paper not available
Comino-Suarez, N., Moreno, J. C., Gomez-Soriano, J. et al. (2021) Transcranial direct current stimulation combined with robotic therapy for upper and lower limb function after stroke: a systematic review and meta-analysis of randomized control trials. Journal of Neuroengineering & Rehabilitation 18(1): 148	- Systematic review used as source of primary studies
D'Anci, K. E., Uhl, S., Oristaglio, J. et al. (2019) Treatments for Poststroke Motor Deficits and Mood Disorders: A Systematic Review for the 2019 U.S. Department of Veterans Affairs and U.S. Department of Defense Guidelines for Stroke Rehabilitation. Annals of Internal Medicine 171(12): 906-915	- Systematic review used as source of primary studies
Da-Silva, R. H.; Moore, S. A.; Price, C. I. (2018) Self-directed therapy programmes for arm rehabilitation after stroke: a systematic review. Clinical Rehabilitation 32(8): 1022-1036	- Systematic review used as source of primary studies
de Sousa, D. G., Harvey, L. A., Dorsch, S. et al. (2018) Interventions involving repetitive practice improve strength after stroke: a systematic review. Journal of Physiotherapy 64(4): 210-221	- Systematic review used as source of primary studies
de-la-Torre, R., Ona, E. D., Balaguer, C. et al. (2020) Robot-Aided Systems for Improving the Assessment of Upper Limb Spasticity: A Systematic Review. Sensors 20(18): 14	- Systematic review used as source of primary studies
Dehem, S., Gilliaux, M., Stoquart, G. et al. (2018) Effectiveness of upper limb robotic-assisted therapy in the early phase of stroke rehabilitation: a single-blind, randomised, controlled trial. Annals of physical and rehabilitation medicine	- Duplicate reference
Dixit, S. and Tedla, J. S. (2019) Effectiveness of robotics in improving upper extremity functions among people with neurological dysfunction: a systematic review. International Journal of Neuroscience 129(4): 369-383	- Systematic review used as source of primary studies

Study	Code [Reason]
Duret, C. (2018) Robotic rehabilitation of the upper limb after a stroke (ROBOASSIST).	- Full text paper not available
Ellis, M. D., Carmona, C., Drogos, J. et al. (2018) Progressive Abduction Loading Therapy with Horizontal-Plane Viscous Resistance Targeting Weakness and Flexion Synergy to Treat Upper Limb Function in Chronic Hemiparetic Stroke: A Randomized Clinical Trial. Frontiers in neurology [electronic resource]. 9: 71	- Study does not contain an intervention relevant to this review protocol
Esquenazi, A., Lee, S., Watanabe, T. et al. (2018) Abstract edited–Supplemental therapeutic conventional vs. robotic upper limb exercise in acute stroke rehabilitation: a randomized, blinded assessor study. Annals of physical and rehabilitation medicine 61(suppl1): e95	- Full text paper not available
Ferreira, Fmrm, Chaves, M. E. A., Oliveira, V. C. et al. (2018) Effectiveness of robot therapy on body function and structure in people with limited upper limb function: A systematic review and meta-analysis. PLoS ONE [Electronic Resource] 13(7): e0200330	- Systematic review used as source of primary studies
Fonte, C., Varalta, V., Rocco, A. et al. (2021) Combined transcranial Direct Current Stimulation and robot-assisted arm training in patients with stroke: a systematic review. Restorative Neurology & Neuroscience 39(6): 435-446	- Systematic review used as source of primary studies
García-Rudolph, A.; Bernabeu-Guitart, M.; Opisso, E. (2020) [Intensities in the application of robotic technologies in upper extremity rehabilitation after a stroke: a systematic review of randomised controlled clinical trials]. Revista de neurologia 70(12): 434-443	- Full text paper not available
Gasperini, G., Rossini, M., Proserpio, D. et al. (2018) Hybrid robotic system combining passive exoskeleton and functional electrical stimulation for upper limb stroke rehabilitation: preliminary results of the retrainer multi-center randomized controlled trial. Annals of physical and rehabilitation medicine	- Conference abstract
Germanotta, M, Pecchioli, C, Cruciani, A et al. (2019) Efficacy of upper limb robot-assisted therapy compared with conventional therapy in	- Full text paper not available

Study	Code [Reason]
stroke patients: preliminary results on a daily task assessed by means of motion analysis. Gait and Posture 74(s): 18	
Hameed, Husamuldeen K., Hassan, Wan Zuha Wan, Shafie, Suhaidi et al. (2020) A Review on Surface Electromyography-Controlled Hand Robotic Devices Used for Rehabilitation and Assistance in Activities of Daily Living. Journal of Prosthetics & Orthotics (JPO) 32(1): 3-13	- Review article but not a systematic review
Hayward, K. S., Kramer, S. F., Thijs, V. et al. (2019) A systematic review protocol of timing, efficacy and cost effectiveness of upper limb therapy for motor recovery post-stroke. Systematic Reviews 8(1): 187	- Study design not relevant to this review protocol
Hsieh, Y. W., Lin, K. C., Wu, C. Y. et al. (2018) Comparison of proximal versus distal upper-limb robotic rehabilitation on motor performance after stroke: a cluster controlled trial. Scientific Reports 8(1): 2091	- Study design not relevant to this review protocol
Hu, X. (2020) Upper limb rehabilitation after stroke assisted with a hybrid electrical stimulation (ES)-robot system.	- Full text paper not available
Hung, C. S., Hsieh, Y. W., Wu, C. Y. et al. (2019) Comparative Assessment of Two Robot-Assisted Therapies for the Upper Extremity in People With Chronic Stroke. American Journal of Occupational Therapy 73(1): 7301205010p1-7301205010p9	- Data not reported in an extractable format or a format that can be analysed *Reports median and interquartile ranges only*
Hung, J. W., Chen, Y. W., Chen, Y. J. et al. (2021) The Effects of Distributed vs. Condensed Schedule for Robot-Assisted Training with Botulinum Toxin A Injection for Spastic Upper Limbs in Chronic Post-Stroke Subjects. Toxins 13(8): 01	- Comparator in study does not match that specified in this review protocol
Hung, J. W., Wu, C. Y., Chang, K. C. et al. (2018) Comparative hybrid effects of combining botulinum toxin A injection with bilateral robot-assisted, mirror or task-oriented therapy for upper extremity spasticity in patients with chronic stroke. Annals of physical and rehabilitation medicine	- Conference abstract
Iamsirikij, C. (2018) Effects of upper limb rehabilitation robot EnMotion® in subacute	- Full text paper not available

Study	Code [Reason]
stroke patients: a single blind randomized controlled trial (robotic rehab, stroke, subacute).	
Kagiyama, T. and Mukae, N. (2020) Clinical research for efficacy and safety of hand-finger rehabilitation robot SMOVE in the goods operation training for the patients with upper limb paresis after recovery stage stroke patients: a pilot study under single center, open-label, randomized, standard therapy controlled trial - (SMOVE pilot study_02).	- Full text paper not available
Kang, T. W., Oh, D. W., Lee, J. H. et al. (2018) Effects of integrating rhythmic arm swing into robot-assisted walking in patients with subacute stroke: a randomized controlled pilot study. International Journal of Rehabilitation Research 41(1): 57-62	- Study does not contain an intervention relevant to this review protocol
Keeling, A. B., Piitz, M., Semrau, J. A. et al. (2021) Robot enhanced stroke therapy optimizes rehabilitation (RESTORE): a pilot study. Journal of NeuroEngineering and Rehabilitation 18(1)	- Study design not relevant to this review protocol *Non-randomised study with sufficient randomised evidence included in the review*
Khalid, S., Alnajjar, F., Gochoo, M. et al. (2021) Robotic assistive and rehabilitation devices leading to motor recovery in upper limb: a systematic review. Disability & Rehabilitation Assistive Technology: 1-15	- Systematic review used as source of primary studies
Kim, S. B., Lee, K. W., Lee, J. H. et al. (2018) Effect of Combined Therapy of Robot and Low-Frequency Repetitive Transcranial Magnetic Stimulation on Hemispatial Neglect in Stroke Patients. Annals of Rehabilitation Medicine 42(6): 788-797	- Comparator in study does not match that specified in this review protocol
Kim, W. S. (2018) Anodal tDCS over the contralesional hemisphere with robotic arm training in subacute stroke patients with severe upper limb hemiparesis.	- Full text paper not available
Kuo, L-C, Yang, K-C, Lin, Y-C et al. (2022) Internet of Things (IoT) Enables Robot-Assisted Therapy as a Home Program for Training Upper Limb Functions in Chronic Stroke: a Randomized Control Crossover Study. Archives of physical medicine and rehabilitation	- Study design not relevant to this review protocol *Crossover trial that only reports results for all of the participants together (does not report results for the first trial period only) - therefore it is not possible to extract results by the methods described in the Cochrane review and so the study is excluded*

Study	Code [Reason]
Lee, H. C., Kuo, F. L., Lin, Y. N. et al. (2021) Effects of Robot-Assisted Rehabilitation on Hand Function of People With Stroke: A Randomized, Crossover-Controlled, Assessor-Blinded Study. American Journal of Occupational Therapy 75(1): 7501205020p1-7501205020p11	- Study design not relevant to this review protocol
Lee, S. H., Kim, W. S., Park, J. et al. (2020) Effects of anodal transcranial direct current stimulation over the contralesional hemisphere on motor recovery in subacute stroke patients with severe upper extremity hemiparesis: Study protocol for a randomized controlled trial. Medicine 99(14): e19495	- Study design not relevant to this review protocol
Leem, Min Jeong, Kim, Gyu Seong, Kim, Kee Hoon et al. (2019) Predictors of functional and motor outcomes following upper limb robot-assisted therapy after stroke. International Journal of Rehabilitation Research 42(3): 223-228	- Study design not relevant to this review protocol
Lin, I. H., Tsai, H. T., Wang, C. Y. et al. (2019) Effectiveness and Superiority of Rehabilitative Treatments in Enhancing Motor Recovery Within 6 Months Poststroke: A Systemic Review. Archives of Physical Medicine & Rehabilitation 100(2): 366-378	- Systematic review used as source of primary studies
Lin, J. C. (2018) Robot-assisted hand rehabilitation for patients with stroke.	- Full text paper not available
Lin, K. C. (2018) Synergistic bilateral upper-limb stroke rehabilitation based on robotic priming technique.	- Full text paper not available
Liu, L. Y.; Li, Y.; Lamontagne, A. (2018) The effects of error-augmentation versus error-reduction paradigms in robotic therapy to enhance upper extremity performance and recovery post-stroke: a systematic review. Journal of Neuroengineering & Rehabilitation 15(1): 65	- Systematic review used as source of primary studies
Lo, K.; Stephenson, M.; Lockwood, C. (2019) The economic cost of robotic rehabilitation for adult stroke patients: a systematic review. JBI Database Of Systematic Reviews And Implementation Reports 17(4): 520-547	- Systematic review used as source of primary studies

Study	Code [Reason]
Marotta, N., Demeco, A., Moggio, L. et al. (2021) The adjunct of transcranial direct current stimulation to Robot-assisted therapy in upper limb post-stroke treatment. Journal of Medical Engineering & Technology 45(6): 494-501	- Systematic review used as source of primary studies
Mashizume, Y; Zenba, Y; Takahashi, K (2020) Novel Mechanism of Action: Efficacy of Upper Extremity Robotic Therapy For Chronic Stroke Patients in Occupational Therapy. Archives of Physical Medicine and Rehabilitation 101(11): e98	- Conference abstract
Mehrholz, J., Pollock, A., Pohl, M. et al. (2020) Systematic review with network meta-analysis of randomized controlled trials of robotic-assisted arm training for improving activities of daily living and upper limb function after stroke. Journal of Neuroengineering & Rehabilitation 17(1): 83	- Systematic review used as source of primary studies
Merians, A. S., Fluet, G. G., Qiu, Q. et al. (2020) Hand Focused Upper Extremity Rehabilitation in the Subacute Phase Post-stroke Using Interactive Virtual Environments. Frontiers in Neurology 11 (no pagination)	- Study design not relevant to this review protocol
Meyer, S., Verheyden, G., Kempeneers, K. et al. (2021) Arm-Hand Boost Therapy During Inpatient Stroke Rehabilitation: A Pilot Randomized Controlled Trial. Frontiers in Neurology 12 (no pagination)	- Comparator in study does not match that specified in this review protocol
Moggio, L., de Sire, A., Marotta, N. et al. (2021) Exoskeleton versus end-effector robot-assisted therapy for finger-hand motor recovery in stroke survivors: systematic review and meta-analysis. Topics in Stroke Rehabilitation: 1-12	- Systematic review used as source of primary studies
Morone, G., Palomba, A., Martino Cinnera, A. et al. (2021) Systematic review of guidelines to identify recommendations for upper limb robotic rehabilitation after stroke. European journal of physical & rehabilitation medicine. 57(2): 238-245	- Review article but not a systematic review
Mubin, O., Alnajjar, F., Jishtu, N. et al. (2019) Exoskeletons With Virtual Reality, Augmented Reality, and Gamification for Stroke Patients' Rehabilitation: Systematic Review. JMIR Rehabilitation And Assistive Technologies 6(2): e12010	- Systematic review used as source of primary studies

Study	Code [Reason]
Park, S. W.; Kim, J. H.; Yang, Y. J. (2018) Mental practice for upper limb rehabilitation after stroke: a systematic review and meta-analysis. International Journal of Rehabilitation Research 41(3): 197-203	- Systematic review used as source of primary studies
Patel, J., Fluet, G., Qiu, Q. et al. (2019) Intensive virtual reality and robotic based upper limb training compared to usual care, and associated cortical reorganization, in the acute and early sub-acute periods post-stroke: a feasibility study. Journal of Neuroengineering & Rehabilitation 16(1): 92	- Study design not relevant to this review protocol
Perini, G., Bertoni, R., Thorsen, R. et al. (2021) Sequentially applied myoelectrically controlled FES in a task-oriented approach and robotic therapy for the recovery of upper limb in post-stroke patients: A randomized controlled pilot study. Technology & Health Care 29(3): 419-429	- Study does not contain an intervention relevant to this review protocol
Perini, G, Lencioni, T, Bertoni, R et al. (2019) Rehabilitation of upper limb in chronic stroke patients: pilot study of functional and neuromotor outcome of a task oriented approach including MeCFES and robotic treatment. Gait and Posture 74(s): 29-30.	- Full text paper not available
Quaglia, D., Gasperi, M., Coser, R. et al. (2018) Robotic rehabilitation effect on upper limb recovery in post-acute stroke. Gait & Posture 66: S31-S32	- Conference abstract
Reis, S. B., Bernardo, W. M., Oshiro, C. A. et al. (2021) Effects of Robotic Therapy Associated With Noninvasive Brain Stimulation on Upper-Limb Rehabilitation After Stroke: Systematic Review and Meta-analysis of Randomized Clinical Trials. Neurorehabilitation & Neural Repair 35(3): 256-266	- Systematic review used as source of primary studies
Remy-Neris, O., Medee, B., Bensmail, D. et al. (2018) Rehabilitation robotics of the upper limb after stroke. The REM_AVC trial. Annals of physical and rehabilitation medicine	- Conference abstract
Rintala, A, Paivarinne, V, Hakala, S et al. (2019) Effectiveness of Technology-Based Distance Physical Rehabilitation Interventions for Improving Physical Functioning in Stroke: A Systematic Review and Meta-analysis of	- Systematic review used as source of primary studies

Study	Code [Reason]
Randomized Controlled Trials. Archives of Physical Medicine and Rehabilitation 100(7): 1339-1358.	
Rosenthal, O. (2018) Performance-based selective training for robot-mediated upper limb rehabilitation after stroke.	- Full text paper not available
Rosenthal, O., Wing, A. M., Wyatt, J. L. et al. (2019) Boosting robot-assisted rehabilitation of stroke hemiparesis by individualized selection of upper limb movements - A pilot study. Journal of NeuroEngineering and Rehabilitation 16(1)	- Comparator in study does not match that specified in this review protocol
Rosenthal, Orna, Wing, Alan M., Wyatt, Jeremy L. et al. (2019) Correction to: Boosting robot-assisted rehabilitation of stroke hemiparesis by individualized selection of upper limb movements - a pilot study. 16: N.PAG-N.PAG	- Correction only
Rozevink, S. G., Hijmans, J. M., Horstink, K. A. et al. (2021) Effectiveness of task-specific training using assistive devices and task-specific usual care on upper limb performance after stroke: a systematic review and meta-analysis. Disability & Rehabilitation Assistive Technology: 1-14	- Systematic review used as source of primary studies
Serrezuela, R. R., Quezada, M. T., Zayas, M. H. et al. (2020) Robotic therapy for the hemiplegic shoulder pain: a pilot study. Journal of Neuroengineering & Rehabilitation 17(1): 54	- Data not reported in an extractable format or a format that can be analysed
Shin, J. H. (2019) Effects of upper extremity rehabilitation robot and transcranial direct current stimulation in chronic stroke.	- Full text paper not available
Suarez-Escobar, M. and Rendon-Velez, E. (2018) An overview of robotic/mechanical devices for post-stroke thumb rehabilitation. Disability & Rehabilitation Assistive Technology 13(7): 683-703	- Review article but not a systematic review
Takebayashi, T., Takahashi, K., Amano, S. et al. (2018) Assessment of the Efficacy of ReoGo-J Robotic Training Against Other Rehabilitation Therapies for Upper-Limb Hemiplegia After Stroke: Protocol for a Randomized Controlled Trial. Frontiers in neurology [electronic resource]. 9: 730	- Study design not relevant to this review protocol

Study	Code [Reason]
Takebayashi, T., Takahashi, K., Domen, K. et al. (2020) Impact of initial flexor synergy pattern scores on improving upper extremity function in stroke patients treated with adjunct robotic rehabilitation: A randomized clinical trial. Topics in Stroke Rehabilitation 27(7): 516-524	- Secondary publication of an included study that does not provide any additional relevant information
Terranova, T. T., Simis, M., Santos, A. C. A. et al. (2021) Robot-Assisted Therapy and Constraint-Induced Movement Therapy for Motor Recovery in Stroke: Results From a Randomized Clinical Trial. Frontiers in Neurorobotics 15: 684019	- Comparator in study does not match that specified in this review protocol
Terranova, T., Simis, M., Santos, A. et al. (2018) Comparing effects of constraint-induced movement therapy and robotic therapy: randomized clinical trial. Annals of physical and rehabilitation medicine	- Conference abstract
Tramontano, M., Morone, G., Palomba, A. et al. (2020) Effectiveness of a sensor-based technology in upper limb motor recovery in post-acute stroke neurorehabilitation: a randomized controlled trial. Journal of Biological Regulators & Homeostatic Agents 34(5suppl3): 165-174. Technology in Medicine	- Full text paper not available
Tsuchimoto, S., Shindo, K., Hotta, F. et al. (2019) Sensorimotor Connectivity after Motor Exercise with Neurofeedback in Post-Stroke Patients with Hemiplegia. Neuroscience 416: 109-125	- Data not reported in an extractable format or a format that can be analysed
Valdes, B. A. and Van der Loos, H. F. M. (2018) Biofeedback vs. game scores for reducing trunk compensation after stroke: a randomized crossover trial. Topics in Stroke Rehabilitation 25(2): 96-113	- Comparator in study does not match that specified in this review protocol
Valkenborghs, Sarah R., Callister, Robin, Visser, Milanka M. et al. (2019) Interventions combined with task-specific training to improve upper limb motor recovery following stroke: a systematic review with meta-analyses. Physical Therapy Reviews 24(34): 100-117	- Systematic review used as source of primary studies
Wright, Zachary A., Majeed, Yazan A., Patton, James L. et al. (2020) Key components of mechanical work predict outcomes in robotic stroke therapy. Journal of NeuroEngineering & Rehabilitation (JNER) 17(1): 1-12	- Data not reported in an extractable format or a format that can be analysed

Study	Code [Reason]
Wu, C. Y. (2020) Robot-assisted therapy combined with mirror priming in upper limb training in stroke.	- Full text paper not available
Wu, J., Cheng, H., Zhang, J. et al. (2021) Robot-Assisted Therapy for Upper Extremity Motor Impairment After Stroke: A Systematic Review and Meta-Analysis. Physical Therapy 101(4): 04	- Systematic review used as source of primary studies
Xu, Q., Li, C., Pan, Y. et al. (2020) Impact of smart force feedback rehabilitation robot training on upper limb motor function in subacute stage of stroke. NeuroRehabilitation	- Full text paper not available
Yuan, R. and Wang, H. (2022) TU-173. The effect of upper limb rehabilitation robot training on the motor function and neuroelectrophysiology of stroke patients. Clinical Neurophysiology 141(supplement): 29	- Conference abstract
Yáñez-Sánchez, A. and Cuesta-Gómez, A. (2020) [Effectiveness of the Armeo ® device in the rehabilitation of the upper limb of stroke's patients. A review of the literature]. Revista de neurologia 70(3): 93-102	- Full text paper not available

Health Economic studies

Published health economic studies that met the inclusion criteria (relevant population, comparators, economic study design, published 2006 or later and not from non-OECD country or USA) but that were excluded following appraisal of applicability and methodological quality are listed below. See the health economic protocol for more details.

Table 11: Studies excluded from the health economic review

Reference	Reason for exclusion
None.	

1

2