Question 30 evidence tables

Question 30: Does robot-assisted training improve arm function after a stroke?

NB Any discrepancies between reviewers in evidence quality and comment were discussed at the corresponding evidence review meeting

ITT = intention to treat, UL = upper limb, LL = lower limb, UC = usual care, ARAT = action research arm test, FMA = Fugl-Meyer Assessment scale, MAL = motor activity log, AFT-FAS = Arm Functional Test-Functional Ability Scale, AFT-T = Arm Functional Test-Time, FMA-UE = Fugl-Meyer Assessment-Upper, MI-EU = Motricity Index of the upper extremity, WMFT = Wolf Motor Function Test, RAT = robot assisted therapy, FES = functional electrical stimulation, CES-D = center for epidemiological studies depression scale, SR = systematic review, MA = meta-analysis, RCT = randomised controlled trial, IPDMA = individual patient data meta-analysis, MDT = multidisciplinary team, PICO = patient/population, intervention, comparison and outcomes, OR = odds ratio, CI = confidence interval, QoL = quality of life, ADL = activities of daily living, OR = odds ratio, RR = relative risk, aOR = adjusted odds ratio, cOR = crude odds ratio, CI = confidence interval, RoB = risk of bias, I2 = heterogeneity statistic.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
840	I. Aprile et al (2020) Upper Limb Robotic Rehabilitation After Stroke: A Multicenter, Randomized Clinical Trial. Journal of neurologic physical therapy. 44: 1.	This RCT compared two groups (control n=124; intervention n=123) at 2wks-6months post stroke -Recruited from 8 centres in Italy (2016-2018). Per site diff not availible -All pts 5/7x45min of treatment RG or CG on top of usual care (6/7 x 45) Incl criteria: -Pts 40-85 -Haem and Infarcts -FMA of 58 or less -Groups were similar at baseline -needed to complete 25/30 sessions to be analysed .	RG: -Four different robotic devices were used and photos of them available in the suppl -Sessions worked on prox and dist UL and included cog component -Vibration also used to inc proprocept -3xsubjects s/v by 1xtherapist (3:1) CG: -1xsubjct seen by 1xtherapist (1:1) -Std UL rehab program described	Measured at T0-Baseline T1-After 6 week treatment T2-3 months after treatment end Blinded FMA – primary outcome Unblinded MI MRC MAS Pain (DN4, NRS) mBI Frenchay ARAT Health survey	Drop out was high and almost half at T2 Per protocol analysis. FMA scores compared between the groups after treatment did not differ significantly (both improved - RG: 8.57 points; CG: 8.57) Secondary analysis limited by drop out and no notable differences between groups.	Acceptable While not explicitly a consequence of study design, the drop-out rate was very high and final analysis was of 122/247 participants enrolled. Authors transparent regarding limitations.

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841	I. Aprile et al (2021). 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. 16: 4. 396-405.	Retrospective secondary analysis of shoulder pain prevalence ('PSSP') in 224 people with stroke enrolled on a randomised clinical trial of robotic vs conventional upper limb therapy. People with first stroke, time since onset 14 to 180 days, aged 40-85, Fugl Meyer score less than 58. Participants from multiple rehabilitation units in original trial.	Robotic group (RG) or conventional therapy (CG). RG treated with robotic and sensor based devices, CG included functional training and task-specific practice. Treatment daily for five days a week for 30 sessions, each 45-minutes.	Fugl-Meyer Upper Extremity (motor function), Motricity Index (strength), Modified Barthel (ADL), SF-36 (QoL). Numerical rating Scale (NRS) for shoulder pain, scored 0-10; considered mild if 1-4 moderate 5-6 and severe if 7 or more Evaluations baseline (T0), after treatment (T1) and three months after end of treatment (T2).	N=224 enrolled, n=190 at T1 and n=122 at T2 (reported as unrelated to adverse events or treatment dissatisfaction but due to distance from centre/lack of assistance in getting to measures). Study evaluated prevalence of pain: PSSP present in 141 cases, 62.9%. Moderate in 17% and severe in 12.1% of cases. In both RG and CG pain changed at end of treatment and follow-up compared to baseline, but no difference T1 to T2. Pain scores evolved similarly.	Secondary analysis.
841	I. Aprile et al (2021). 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. 16: 4. 396-405.	Secondary analysis of multicentre RCT comparing UL conventional or robotic rehabilitation. Study aimed to evaluate prevalence/characteristics of PSSP, and analyse correlations between PSSP and rehab outcomes. 224 subjects; 8 centres Sub acute.	Robotics – Motore, Humanware, Amadeo Conventional care – sensory stim, stretching, passive mob, functional training. Both groups – 45mins, 5 days p/w, 30 sessions.	Post stroke shoulder pain (numeric rating scale and Douleur Neuropathique 4)' UL motor function, strength and disability – at baseline, after 30 rehab sessions, after 3 m.	Moderate/severe pain reported in 28.9% of patients. Intensity higher in women and those with neglect. Reduction in pain after treatment in both groups. Pain at baseline similar between 2 grps. Pain reduced post intervention in both groups – maintained at 3m follow up. No differencs reported between grpas	**+** Acceptable quality. Would need to go back to original RCT to fully review.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
842	H. Bosomworth et al (2021). Evaluation of the enhanced upper limb therapy programme within the Robot-Assisted Training for the Upper Limb after Stroke trial: descriptive analysis of intervention fidelity, goal selection and goal achievement. Clinical rehabilitation. 35: 1. 119-134.	To report the fidelity of the enhanced upper limb therapy programme within the RATULS RCT the types of goals selected, and goals achieved. A descriptive analysis of data. 259 participants from the enhanced UL programme-adults from the (RATUALS trial). Moderate -severe UL ARAT 0-39 between one week and 5 years post first stroke. One week and five years of their first stroke. Moderate to severe arm weakness. (ARAT 0-39) Setting -outpatient stroke rehabilitation within 4 UK NHS centres.	Intervention: Enhanced UL therapy programme: Repetitive task practice, goal setting (no more than 4 goals at one time), provided 3 sessions per week for 12 weeks (36 sessions in total). Sessions 45 mins. Mainly delivered by Physio/OT assistant. Qualified therapist monitored every 4 weeks. Sessions included: repetitive functional task practice on personal goals, stretching, education, monitoring, compensatory movements, feedback. Following recorded: duration of session, face to face, number of repetitions per task, goals selected, type of task practice.	ARAT Number of repetitions Goals selected and achieved: Canadian Occupational Performance Measure (CMOP)	84% of sessions were attended. 91% of the target of 27 hours of face to face therapy was achieved. Median of 127 reps achieved per participant per session. Overall proportion of goals achieved -low (51%). Goals related to self-care most selected (54%), Productivity (14%), Leisure (7%) Median of 12 goals were selected per participant during the 12-week UL Programme.	- Amount of therapy provided in the enhanced UL programme is low. Generalisation findings cannot be generalised.
842	H. Bosomworth et al (2021). Evaluation of the enhanced upper limb therapy programme within the Robot-Assisted Training for the Upper Limb after Stroke trial: descriptive analysis of intervention fidelity,	Descriptive design of data on fidelity, goal selection and achievement from an intervention group within a RCT (RATULS). 259 Moderate-Severe upper limb activity limitation between one week to five years post first stroke.	36 one-hour sessions including 45 minutes of face to face therapy focusing on personal goals. Randomized to receive robot assisted training, an enhanced UL programme (repetitive functional task practice	COPM, ARAT, Fugl-Meyer, Stroke Impact Scale and Barthel.	84% of sessions were attended. Available data for 2051/2665 goals and 51% of goals were achieved. Little difference in ARAT score at three months between groups. Enhanced UL therapy programme performed	**+** Trial participants were younger than the average stroke population 60 vs 75 years. Recruited up to five years after stroke so proportion had a poor prognosis for recovery.

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	goal selection and goal achievement. Clinical rehabilitation. 35: 1. 119-134.	Study in the UK.	on personal goals or usual care.		better than usual care at 3 months on Fugl-Meyer and Stroke Impact Scale. Patients randomized to receive the enhanced UL programme performed better than those randomized to receive robot-assisted training in measures of ADL on Stroke Impact Scale and Barthel.	Self reported outcomes may have been influenced by self practise.
843	Budhota et al (2021). Robotic Assisted Upper Limb Training Post Stroke: A Randomized Control Trial Using Combinatory Approach Toward Reducing Workforce Demands. Frontiers in Neurology. Jan-03.	RCT n=44 subacute and chronic stroke survivors (3-24/12 post stroke) UL deficit (FM 20-50) or motor ataxia Outpatient setting	RT (60 min minimally supervised RT and 30 mins conventional therapy) vs Control (90 mins conventional therapy) three times a week for six weeks.	Clinical outcomes: FM ARAT Grip strength Adverse events: Pain, spasticity Robotic assessment tasks: line tracing, circle tracing. OMs complete at week 0, week 3 (midway), week 6 (end) and follow up at week 12 and 24.	Clinical outcomes: Both groups improved. No stat sig diff between groups for FM, ARAT and grip strength at the end of treatment and follow up. Robotic assessment: Line tracing both groups improved robotic assessments. No sig dif between groups. Circle Tracing: Stat sig higher smoothness in RT group at the end of therapy ($p<0.05$).	**+** Small sample size No details on standardisation of rx between therapists. No mention of ITT analysis.
843	Budhota et al (2021). Robotic Assisted Upper Limb Training Post Stroke: A Randomized Control Trial Using Combinatory Approach Toward Reducing Workforce Demands.	A prospective, single-center (Singapore), non-inferiority, outpatient randomized controlled trial with equal (1:1) allocation treatment groups (n=22 per group). Subjects – 44 subacute to chronic stoke patients.	Both groups received 90 mins of treatments, 3 times a week for 6 weeks. Intervention group: 60 mins of conventional therapy and 30 mins using H Man	Motor impairment scale FMA (as primary outcome), ARAT Grip Strength Plus some quantitative measures performed on the robot.	Both groups improved their scores at a similar rate and degree and maintained improvement post treatment improvement at follow up (24 weeks). There was no significant	**+** This is a small but reasonably well conducted single centre RCT. Showing that similar improvements in arm impairment scores are achieved and

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	Frontiers in Neurology. Jan-03.	Inclusion criteria: first-ever stroke; age 21 to 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: capacity to consent.	- a shoulder elbow robot at each session. Comparison group 90 mins conventional therapy, per session. Conventional therapy involved: passive mobilization; active-assisted approaches based on neuro-developmental techniques to enhance normal movement patterns, repetitive tasks, specific training for functional reach training; use of upper limb inclined board and motorized arm bike.	Assessed immediately post training 6 weeks and at follow ups at weeks 12 and 24. Note the authors identified a need to investigate the effects of a combined therapy and robot assist therapy approach on ADL performances and whether the effects therapy are retained after the training, but they did not include an ADL measure and furthermore the study is too small to determine a meaningful difference in ADL performance.	differences between groups at any of the time points. There were no training-related adverse side effects. The authors conclude that time matched combinatory training incorporating H-Man RAT produced similar outcomes compared to conventional therapy alone The graphs in the article bear this out Results in the paper are not expressed as mean differences and confidence intervals.	maintained with a combined approach as are achieved by the same amount of 1:1 conventional therapy.
844	R. S. Calabro et al (2021). Robot-assisted training for upper limb in stroke (ROBOTAS): An observational, multicenter study to identify determinants of efficacy. Journal of Clinical Medicine. 10: 22. 5245	Setting: 18 neuro-rehab centres Design: Observational multicentre Subjects: N=105 Incl. criteria: Adult First time stroke Independent sit Exclusion criteria: Bilateral UL impairment Cognitive or physical impairment that precludes participation	Electromechanically assisted arm training in addition to conventional therapy (either an exoskeleton or an end-effector device) 20 sessions x 3 or 5/7 for 40 mins 6-8/52 as per usual care However, "Overall, each participant was provided with one-hour daily	At baseline (T0), post intervention (T1) & 3/12 (T2) Fugl-Meyer Assessment for the upper extremity (FMA-UE). Secondary: Motricity Index (MI), Box & Block Test (B&B), Numerical Rating Scale (NRS), Frenchay Arm Test (FAT), Barthel Index	Groups @ baseline Exo: FMAUE = 19, BI = 36 17/65 (26%) early subacute End Effector FMAUE = 28, BI = 49 26/40 (65%) early subacute So - End Effector were more acute & impaired at baseline	- Observational study, no blinding, no control, "lack of rigid standardization of the interventions Implemented". Some confusion & lack of clarity in the text.

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		BTX-A Stratified as to chronicity (<30days/30-60days/>60days), impairment and age (<50/50-70/70+)	UL robotic training regardless of the robot type” Exo: n=65 Functional movements assisted by robots at the shoulder, elbow & wrist with video feedback. Assistance progressively reduced according to improvement/capacity End-effector: n=40 “The intervention with the end-effector devices included the same amount of training, although the mechanism by which UL was treated was different”.	(BI) & Modified Ashworth Scale (MAS).	Between group diff: FMA-UE improved at T1 by 6 points on average in the end-effector group and 11 points on average in the exoskeleton group ($p < 0.0001$). Subgroup: Exoskeletons were more effective in the more severe patients (OR = 2.66, $p = 0.002$), whereas end-effectors offered better results in the mild-to-moderate patients (OR = 1.9, $p = 0.02$).	
844	R. S. Calabro et al (2021). Robot-assisted training for upper limb in stroke (ROBOTAS): An observational, multicenter study to identify determinants of efficacy. Journal of Clinical Medicine. 10: 22. 5245	Prospective, multicentre, observational cohort study involving 18 neuro rehabilitation centres in Italy (n=105) In addition to usual care all patients received either Exoskeleton or end-effector robot therapy Limited baseline demographics provided though baseline differences seem probable and there is	Six different robots used. -Exoskeleton x 2 (n=65) -End-affector x 4 (n=40) Described with some discrepancy: “each participant was provided with one-hour daily UL robotic training regardless of the robot type” For both groups “included 20 sessions of 40 min (including 10 min	Measured at T0-Baseline T1-After 6-8wk treatment T2-3mo follow-up Primary FMA T0-T1 change Secondary MI BBT NRS Frenchay BI MAS	FMA improved at T1 by 6 points on average in the end-effector group and 11 points on average in the exoskeleton group.	- Small sample and limited longitudinal follow-up for a cohort study (3month). Intervention dose poorly defined. Limited information provided on the cohort and a number of other factors. Aim was to evaluate/compare robot

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		differences between the different robot groups Incl: 1st stroke, UL impairment Excl: Cog impairment, bilat UL impairment, Botox.	for setup), 3 or 5 times per week for 6–8 weeks".			devices in real world setting, however evaluation goes beyond feasibility.
845	I. Carpinella et al (2020). Effects of robot therapy on upper body kinematics and arm function in persons post stroke: a pilot randomized controlled trial. Journal of NeuroEngineering and Rehabilitation. 17: 1.	Setting: Unclear Design: RCT Computer randomisation Subjects: N=40 recruited and 38 completed Incl. criteria: 18+ NIHSS UL 1-3 (movement but impaired) FM-UE >6 (out of 66) Excl. criteria: MMSE<20	20 sessions with PT 45 mins x 5/7 Robot Group (RG) N=15 5 targets around 20cm circ. Either assistance as needed or resistive modes. All start with assistance & data reviewed each session. Assistance / rigidity adapted according to data & clinical reasoning – rationale detailed. Usual Care Group (UCG) N=17. Described & ref.	Blinded Ax @ baseline & post intervention Instrumental Ax of move & place test to ascertain: - shoulder / elbow coordination index - Shoulder flex (deg) - Elbow ext (deg) - Trunk compensation Fugl-Meyer Upper extremity (FM-UE) Reaching performance scale (RPS) Functional Independence Measure (FIM) Modified Ashworth (MAS)	Stat sig diff between groups - R_Group showed larger improvements in shoulder/elbow coordination, elbow ext & decreased trunk compensation. Both groups showed comparable improvements in shoulder flex & clinical scales, except proximal muscle MAS that decreased more in R_Group. Sub-analyses suggest larger improvements after robot-therapy in the proximal portion of FM-UE for chronic group Used ITT and detailed those lost.	**+** Only concern is how different it is to the Lencioni 2021 write up of the same study. Caveat – small study and single plane gravity eliminated robotic. Hypothesised that this may be related to intensity of repetition, ability to engage and succeed as well as providing a variety of feedback options formats for patients – all of which optimise opportunities for learning.
846	F. Cecchi et al (2021). Age is negatively associated with upper limb recovery after conventional but not	Secondary analysis of RCT comparing robotic therapy and conventional treatment for upper limb after stroke (paper ID2 above) . Aim to	Robotic group (RG) or conventional therapy (CG). RG treated with robotic and sensor-based	Fugl-Meyer upper extremity FMA-UE (motor response; categorised according to severity-severe, moderate, mild).	Age was only baseline variable associated with recovery, in the CG. No variables in RG were	Secondary analysis.

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	robotic rehabilitation in patients with stroke: a secondary analysis of a randomized-controlled trial. Journal of Neurology. 268: 2. 474-483.	identify characteristics that might predict response to robotic or conventional therapy. 190 people with stroke , inclusion according to studies ID2/3 above.	devices, CG included functional training and task-specific practice. Treatment daily for five days a week for 30 sessions, each 45-minutes.	Evaluated at baseline and at end of 30-session rehabilitation intervention (robotic or conventional), Baseline variables examined included age, time since stroke, impairment, neglect, language impairment.	associated with outcome.	
846	F. Cecchi 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 analysis of RCT – focussed on predictors of response to treatment. Examined which baseline variables are associated with the response to conventional/robotic rehab. Data from 190 patients; 8 centres in Italy. 14-180 days post stroke. Change > or = to 5 on FMUE considered a good response.	45mins, 5x week, 30 sessions. 3 types of robotic devide: Morotre, Amadeo, Pablo).	Fugl Meyer UE.	121 (64%) of patients classified as "responders". Age, severity and neglect were significantly different btwn responders and non-responders. Age was the only factor negatively associated with recovery in the conventional care group, but not the robotic group.	**+** Would need to go back to original RCT to fully review.
847	Z. Chen et al (2020). Robot-Assisted Arm Training versus Therapist-Mediated Training after Stroke: A systematic review and meta-analysis. Journal of Healthcare Engineering. 2020.	Systematic review and Meta Analysis. PROSPERO China. 35 trials with 2241 participants met inclusion criteria. Articles were searched for effect size and MCID. -inclusion criteria were (1) randomized controlled trials or randomized controlled crossover trials; (2) patients diagnosed with stroke and	We included randomized controlled trials (RCTs) and randomized controlled crossover trials -Therapist-mediated training was defined as impairment-oriented or function-oriented upper limb training tailored by therapists to the individual's impairment	Primary outcomes. – Fugl-Meyer Assessment of the Upper Extremity (FMA-UE) Secondary outcomes activities of daily living, and social participation (ICF) framework, Due to numerous outcome measures used across trials, implemented the selection:	-Study sizes ranged from 20 to 770. Time per session ranged from 30 minutes to 5 hours. Duration of the intervention ranged from 2 weeks to 12 weeks training -Motor impairment=29 trials recruiting 1682 participants measured upper limb motor	**++** Systematic review and meta-analysis showed that robot assisted training was slightly superior in motor impairment recovery (not greater than MCID) and noninferior to therapist-mediated training in improving upper limb capacity, activities of daily living, and social participation.

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		having upper limb motor dysfunction; (3) studies investigating the effects of robot-assisted arm rehabilitation compared with therapist-mediated training; (4) outcome measures including arm motor impairment, capacity, and activities of daily living or social participation. -Two authors read the titles and abstracts independently. Disagreements were resolved by discussion or by consultation with an adjudicator.	or requirements, including conventional occupational therapy, physical therapy, task-specific training, ADL training, and constraint-induced movement therapy (CIMT). In addition, robot-assisted training was either the only training program or performed in combination with conventional arm training in a trial setting	If more than one measure was available, we prioritized (ARAT), Wolf Motor Function Test (WMFT), Box and Blocks Test (BBT), Nine Hole Peg Test (CAHAI), Arm Motor Ability Test (AMAT) Assessed ADLs by prioritizing (FIM), Barthel Index (BI), Motor Activity Log (MAL), and modified Rankin Scale (mRS). Assessed social participation with the order of priority by Stroke Impact Scale (SIS)	impairment Robot-assisted training showed a statistically significant mean effect size in motor impairment and was superior compared with therapist mediated training. Upper Limb Capacity. 26 trials recruiting 1557 participants measured upper limb capacity. Robot-assisted training was not associated with statistically significant improvement in upper limb capacity. Activities of Daily Living (ADL). 26 trials recruiting 1468 participants measured activities of daily living (ADL). Robot-assisted training was not associated with statistically significant improvement in ADL. -Social Participation. 8 trials 849 participants measured social participation. Robot-assisted training was	

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					not associated with statistically significant improvement in social participation,	
847	Z. Chen et al (2020). Robot-Assisted Arm Training versus Therapist-Mediated Training after Stroke: A systematic review and meta-analysis. Journal of Healthcare Engineering. 2020.	Systematic review and analysis of robot assisted arm training v's therapist mediated training after stroke. Set in China. 35 trials with 2241 participants.	Robot assisted training versus therapist mediated therapy. Therapist mediated therapy was defined as impairment-oriented or function-oriented upper limb training including OT, PT, task specific training, ADL and CIMT.	Primary outcome – Fugl-Meyer. Secondary outcome – ARAT, Wolf Motor Function, Box and Block test, nine hole peg test, chedoke arm and hand activity inventory and Arm motor ability test. ADL – FIM, Barthel, Motor activity and modified rankin. Social participation – Stroke impact scale and SF36.	Demonstrated that robot-assisted training was slightly superior in motor impairment recovery . Non inferior to therapist mediated training in improving arm capacity, ADL or social participation.	**+** No evidence of optimal training of robot use or effects of RAT feedback, contents and games. No discussion of costs/safety. Studies were time matched not repetition matched.
848	W. T. Chien 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.	SR and MA 11 RCTs, n=493 18-65 At least 60% had primary dx of 1st stroke Subacute stroke (<6/12 post stroke)	Robotic therapy (RT) vs usual care	Motor Control:FM Fx Indep: FIM, BI, Activlim questionnaire. UL Performance: ARAT Wolf Motor Fx Test Quick DASH Muscle Tone: MAS QoL: SIS	Motor Control: No sig diff (SMD:0.18, 95%CI -0.16 – 0.51, p=0.31). Fx Indep: No sig diff (SMD:0.40, 95%CI-0.16-0.95, p=0.16). UL performance: No sig diff (SMD: 0.01, 95%CI –0.28-0.3, p=0.96). Tone: No sig diff (SMD-0.04 95% CI -0.38-0.30, p=0.81).	**++** But included studies were of low to moderate quality.

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					QoL: No dif diff (SMD: 0.03, 95% CI -0.30-0.36, p=0.86).	
848	W. T. Chien 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.	Systematic review and meta-analysis of the effects of robot assisted therapy compared to usual care on 5 outcomes in patients within 6 months post stroke. Inclusion criteria of trials: RCTs published from 2000-2019 Patients included were at least 60% with diagnosis of 1st ever stroke, aged 18-65 years, post stroke period ≤6 months.	Robot therapy including: Robot integrated physiotherapy; home based robot tele-rehabilitation; robot training combined with games; robot bilateral training. The robot therapy was reported as stand alone therapy or was an adjunct to conventional usual care therapy. Control conditions any type but not including robot therapy.	ICF: body function primary outcome was ‘motor control, this was usually FMA. Secondary outcomes: Functional independence usually FIM, Barthel Upper extremity performance – Wolf MFT, ARAT, Quickdash Muscle tone – modified ashworth Quality of Life – stroke impact scale Within each scores were converted to standard mean differences.	11 RCTs included. Involving 493 participants. Four RCTs were considered at high risk of bias; four were rated as some concerns and three were judged low risk. At posttreatment, the effects of RT when compared to usual care on motor control, functional independence, upper extremity performance, muscle tone, and quality of life were nonsignificant. All forest plots showed summary 95% confidence intervals straddling 0.	**+** Acceptable quality conducted according to PrISMA guidelines and Cochrane review guidelines, but I cannot be sure of how the results from the three study with high risk of bias were treated though the authors do say results should be treated with caution due to the quality. Results show robot assisted therapy produced similar effects to usual care for improving all 5 outcomes in patients who are within the first 6 months post stroke. Authors suggest future studies should be non-inferiority or equivalence trials as equivalent results are valuable in considering resources.
849	K. H. Cho; W. K. Song (2019). Robot-Assisted Reach Training With an Active Assistant Protocol for Long-Term Upper	Setting: National Rehab centre (community dwelling) Design: RCT	Robot-assisted reach training with assist-as-needed (RT-AAN) 40 mins x 3/7 x 6/52	Fugl-Meyer Assessment (FMA), Action Research Arm Test (ARAT), Box and Block Test Kinematics	Both groups showed significant improvement in FMA, ARAT, and kinematics However, the RT-AAN group showed	**-** Low quality. No ITT.

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	Extremity Impairment Poststroke: A Randomized Controlled Trial. Archives of Physical Medicine and Rehabilitation. 100: 2. 213-219.	Subjects: N=38 Chronic stroke survivors (42 enrolled, 3 withdrew and 1 lost to follow-up)) Criteria: 6/12+ post stroke MMSE >24 No neglect No subluxation No pain No spasticity (MAS >2).	Both wore whole arm manipulator (WAM) and had gravity eliminated whilst reaching for targets with visual & auditory feedback Robot-assisted reach training with guidance force (RT-G) 40 mins x 3/7 x 6/52	Baseline & 3/7 post last session. Training and Ax completed by OT / PT who were blinded (??) Baseline BI & FMA-UE were pretty high (95 +/-3.9 & 48.47 +/- 10).	significantly more improvement than the RT-G group in FMA and ARAT – very different actions and points to potentially different mechanisms (pre-motor cortex & limbic engagement if pts are initiating / planning and executing compared with passive motion).	Questionable blinding. Only mildly impaired UL's – required the ability to have secure distal reference which may be a challenge to UL's in the inpatient setting, however not practical for use in patients home
849	K. H. Cho; W. K. Song (2019). Robot-Assisted Reach Training With an Active Assistant Protocol for Long-Term Upper Extremity Impairment Poststroke: A Randomized Controlled Trial. Archives of Physical Medicine and Rehabilitation. 100: 2. 213-219.	RCT comparing two Robot based protocols, one using assistance, the other, guidance. n=38. -Based in Korea -Subjects were community dwelling -6months or more since stroke Excluded: Neglect, sublux or limb pain -Single follow-up time point for outcome measures.	Both groups: -Utilised a WAM (whole arm manipulator) Robot - 40 minutes per day, 3 times per week over a 6-week period. Group 1 - RTAAN: which provides triggered assistive force based on the participant's reaching performance. Group2 - RTG: which provides constant assistive force to correct arm movements smoothly in a specified trajectory.	FMA ARAT BBT Kinematic data (from the robot set to compensate for gravity, but not assist or guide movement)	RTAAN (Assist as needed group) improved… -FMA by 2 points more that the RTG (Guidance group) -ARAT by 3.34 points more than the RTG group While results for ARAT and FMA were p value significant. Levels are below the MDC95 and MCID for these measures Per-protcol analysis and powered for n=20 per group. Final analysis was n=19 per group.	Acceptable.
850	K. H. Cho; W. K. Song (2021). Effects of two different robot-assisted arm	RCT n=40 chronic stroke survivors. Outpatient setting.	RT with Whole Arm Manipulator (WAM) vs RT with Proficio, 40 mins daily, 3/7, 4/52.	FM – proximal / distal ARAT Box and block test Curvilinearity ratio .	Both groups significantly improved in FMA, ARAT, box and block test (p<0.05).	**+** Adequate power.

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	training on upper limb motor function and kinematics in chronic stroke survivors: A randomized controlled trial. Topics in Stroke Rehabilitation. 28: 4. 241-250.				RT Proficio stat sig improvement in FM-distal over RT WAM (p<0.05).	No ITT analysis, excluded drop outs.
851	S. S. Conroy et al (2019). Robot-Assisted Arm Training in Chronic Stroke: Addition of Transition-to-Task Practice. Neurorehabilitation and Neural Repair. 33: 9. 751-761.	Single-blinded RCT of robot therapy vs robot therapy (RT) plus therapist assisted transition-to-task therapy (TTT). N=45 people enrolled of 127 screened, from clinics and community settings. Adults with stroke, unilateral hemiparesis, Fugl Meyer (FM) score 7 to 38- stratified by moderate or severe at randomisation.	Both groups received intervention for one hour, 3 times per week for 12 weeks, but RT group: 60 mins of robot training and TTT group: 45 minutes robot training plus 15 minutes of TTT. @ robots used in four-week progressive training blocks, distal training preceding proximal. TTT was progressive using everyday objects e.g. robot-trained wrist ext/radial deviation was followed by training to flick switch/lift cup etc.	Primary outcome: change in Upper Extremity Fugl Meyer Score (UE-FMA) baseline to 12 weeks (final training) Secondary: UE FMA proximal and distal sub-scores; Wolf Motor Function Test (WMFT); Stroke Impact Scale, hand section (SIS).	N=22 in RT group and n=23 in TTT group at baseline, n=19 RT and n=22 TTT at outcome. FMA change post-training (12 weeks) did not differentiate the groups. Similar impairment gains in both. Significant gains within both groups. Significant between groups change for WMFT and SIS at week 12. Fewer reps in TTT group, with 25% less RT accounted for.	**-** As although detail given of stratification the actual randomisation and allocation concealments methods were not clear.
851	S. S. Conroy et al (2019). Robot-Assisted Arm Training in Chronic Stroke: Addition of Transition-to-Task Practice. Neurorehabilitation and Neural Repair.	Single blind RCT. > 6 months post stroke Randomisation stratified according to baseline FM. 45 participants.	RAT combined with therapist assisted task training, versus RAT alone. Grp 1 60 mins RAT.	FM UE WMFT SIS . Assessor blind	Both groups improved. No differences between groups in any OCM NO difference in sub-group analysis (according to baseline severity).	**+** Adequate quality.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	33: 9. 751-761.		Grp 2: 45 mins RAT and 15 mins therapy assisted transition to task training 3x per week, 12 weeks, max 36 visits.			
852	C. Fernandez-Garcia et al (2021). 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. 11: 5. e042081.	To determine whether robot-assisted training is cost - effective compared with an enhanced UL therapy (EULT) programme or usual care. Design: Economic evaluation with a RCT. Setting: 4 NHS centres in the UK. Participants: 770 participants moderate to severe UL functional limitation from first -ever stroke.	Participants randomised to one of three programmes over 12 weeks. Robot-assisted training plus usual care, EULT programme plus usual care or usual care.	Main economic outcome measure: Mean healthcare resource use; costs NHS and personal social services in 2018 pounds; utility scores based on EQ-5D-5L responses and quality-adjusted life years (QALYs) Cost-effectiveness reported as incremental cost per QALY and cost effectiveness curves.	RATULs found no evidence that robot assisted training improved UL function compared to EULT and usual care. Low dose of EULT and robotic therapy.36 sessions) Cost effectiveness analysis suggested that neither robot assisted training nor EULT as delivered in this trial were likely to be cost effective at any of the cost per QALY	**-** Limitations: Low dose of EULT and Robotic therapy. Unavailability of longer - term data for the within trail evaluation means no robust inferences could be made on the long -term cost effectiveness of the interventions. Unsure what usual care was.
852	C. Fernandez-Garcia et al (2021). 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	RCT trial studying the economic evaluation of robot assisted training , enhanced upper limb therapy programme and usual care. Set in the UK, Four centres. Patients were recruited from stroke units, day hospitals, outpatients, community rehab and stroke clubs.	Three programmes over a twelve week programme.: Robot assisted training and usual care Enhanced UL programme plus usual care Usual care.	Primary outcome ARAT at baseline and three months. QOL outcome measure for the economic evaluation was EQ-5D-5L at baseline, three and six months.	The cost effectiveness analysis suggested that neither robot assisted training nor EULT as delivered in the trial were likely to be cost effective at any of cost per QALY thresholds considered. RATULS found not evidence that robot assisted training as	**+** Utility scores based on EQ-5D-5L may not accurately capture changes in quality of life for this patient group. Poor completion of arm therapy logs meant that detailed information on the delivery of usual care

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	randomised controlled trial. BMJ Open. 11: 5. e042081.	770 participants aged 18 years or older with moderate or severe UL function from a first ever stroke as measured on the ARAT (0-39).			delivered in this study improved UL function success for patients with a moderate or severe UL functional limitation compared to EULT programme or usual care.	was from a health service utilisation questionnaire. Limitation of the economic evaluation is associated with the time frame of the trial.
853	M. Franceschini et al (2020). Upper limb robot-assisted rehabilitation versus physical therapy on subacute stroke patients: A follow-up study. Journal of Bodywork and Movement Therapies. 24: 1. 194-198.	Six month follow up of multicentre RCT n=48 Subacute stroke patients Moderate to severe UL impairment FM 7-38.	Initial RCT intervention was end-effector robotic therapy (RT) vs control group (CG) of traditional UL physio. Both received 30 sessions (5/7 for 6/52).	Primary: FM-UE Secondary: pROM for shld and elbow MAS-Shoulder MAS-Elbow OMs are compared from end of treatment (T1) to six month follow up (T2).	FM-UE: Both groups showed stat sig improvement but greater increase in RT. MAS-Shoulder showed a stat sig increase in spasticity in CG only (p=0.042). RT had higher pROM (p=0.003) and lower MAS-shoulder (p=0.032) in follow up.	- Added in people for dropouts from original study but still underpowered. Difference between groups FM-UE at baseline but not stag sign. Small sample size.
853	M. Franceschini et al (2020). Upper limb robot-assisted rehabilitation versus physical therapy on subacute stroke patients: A follow-up study. Journal of Bodywork and Movement Therapies. 24: 1. 194-198.	A randomized controlled follow-up study to analyse the long-term effects (6 months follow-up) of upper limb Robot-assisted Therapy compared to Traditional physical Therapy. Setting: 2 Italian rehabilitation centres. 48 Subacute stroke patients stroke survivors	Intervention group performed 30 sessions (5 days/week for 6 weeks) of robot training for the shoulder and elbow comprising 675 movements to targets in a planar dimension. Up to 45 mins duration. Control group CG performed 30 sessions (5 days/week for 6 weeks) of upper limb traditional physical	Primary outcome measure upper limb portion of FMA. Secondary outcome Passive ROM (sum of shoulder and elbow movements (shoulder flexion/extension, abduction, intra/extra rotation and elbow extension) in order to assess joint ranges correlated to	On the primary outcome FMA - The groups were not similarly impaired at baseline T0 control group median 24.0 [IQR7.5; 38.3] experimental group median 32.0 [17.8; 38.0] At T1 (end of treatment, the control group had not changed from baseline) T1 23.0 [10.3; 44.3] but by T2 there	- Many quality details were not given in this report of the follow up results. They may well be in the previous paper reporting the trial. The conclusions that can be drawn are that changes in the robot therapy group at the end of the treatment period were maintained at follow up.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		Inclusion criteria for the RCT were: (a) first acute event of cerebrovascular stroke; (b) unilateral moderate to severe paresis: score between 7 and 38 of the upper limb part of FMA (which has max of 66 points); (c) ability to understand and follow simple instructions; (d) ability to maintain a sitting position.	therapy, with the number and type of movements matched to the robot-assisted therapy: assisted stretching, shoulder and arm exercises, and functional reaching tasks. All subjects underwent conventional physiotherapy sessions according to an individually tailored exercise scheduling.	spasticity; Modified Ashworth Scales for spasticity.	were median of 8 points better.31.0 [15.5; 39.3] The experimental group changed by median 11 points from baseline to T1 and then a further 2 points to T2. T1 median 43.0 [28.5; 48.0] T2 45.0 [33.8; 50.0]	However, conclusions comparing the groups are confounded by the difference in the primary outcome between groups at baseline. Because the control group were more impaired at baseline their recovery profile would have been longer and slower. So do not think the statistical differences between reported are due to the study intervention.
854	Y. W. Hsieh et al (2020). Comparison of proximal versus distal upper-limb robotic rehabilitation on motor performance after stroke: a cluster controlled trial. Scientific reports. 8: 1. 2091.	Setting: Outpatient Design: Cluster controlled trial. 2 hospital sites per cluster, randomised by research assistant Subject: N=40 (started with 44) Incl criteria: 6/12+ post stroke FMA of 18-56 MMSE>24 MAS 3 or less Excl. criteria: Joint pain	20 sessions 90-100 mins, 5/7 x 4/52 InMotion ARM (P-IMT) n=15 Table support, shoulder elbow unit with 2 degrees of freedom InMotion WRIST (D-IMT) n=13 Forearm in trough and gripping end-effector. Wrist flex / ext/ abd/ add and pro/ supination. For both RT groups: Video feedback, high reps (1024), PT encouragement for clock games “active-assisted	Blind @ baseline & post Rx Primary: Fugl-Meyer Assessment (FMA) & Medical Research Council (MRC) scale. (“proximal” “distal” and “average” MRC scores) Secondary: Motor Activity Log (MAL) and wrist-worn accelerometers Although not stat sig DIMT group were 50 yrs and 14.9 months post stroke and PIMPT were 57 & 21.7 months post stroke.	stat significant differences in the distal FMA, total MRC & distal MRC scores among the 3 groups (P = 0.02 to 0.04). D-IMT group had stat significantly better outcome than the P-IMT group on the total MRC (P = 0.04) and distal MRC (P = 0.04). The D-IMT group also showed stat. significant greater improvements than the CT group on the distal FMA (P = 0.03) and distal MRC (P = 0.04).	- No ITT Averaging “distal MRC” – needs some unpacking Small sample sizes Differences in groups at baseline Young sample Lack of detail regarding contribution of modes of RT Questionable attempt to isolate distal activity when against gravity – despite UL

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			mode was mainly applied in this study" – but other options (passive and resistance available) 40-50 mins of RT followed by 40-45 mins functional task training. Control n=12 45 mins conventional therapy and 45 mins functional task training		No sig diff between 3 groups in total FMA, prox FMA and prox MRC No ITT Young sample	support in trough – anticipatory postural activity?
854	Y. W. Hsieh et al (2020). Comparison of proximal versus distal upper-limb robotic rehabilitation on motor performance after stroke: a cluster controlled trial. Scientific reports. 8: 1. 2091.	-Cluster randomised at 6 hospitals. Taiwan -n=44 (40 analysed, 4 dropped out, 70 declined to take part) -recruited from OT clinic, at least 6months post stroke -3 groups compared P-IMT, D-IMT, or CT.	All participants received 20 sessions (90 to 100minutes per session, 5dpw, for 4 weeks. P-IMT(n=15): proximal-emphasized robotic rehabilitation by using the InMotion ARM. D-IMT(n=13): Distal-emphasized robotic rehabilitation by using the InMotion WRIST. CT(n=12): Control 45min of conventional rehab and 45min of functional task practice per session. Does not specify proximal or distal focus.	Assessed blindly at baseline and immediately following 4-week intervention FMA – primary MRC MAL Wrist accelerometers	Authors claim: Our findings suggest that distal upper-limb robotic rehabilitation using the InMotion WRIST system had superior effects on distal muscle strength However… Mean difference FMA at follow up for the groups was: PIMT: 4.47 (3.21–5.72) DIMT: 4.92 (3.28–6.57) CT: 4.25 (2.81–5.69) None of these improvements exceed the MCID for the FMA nor appear different overall (primary outcome) On sub-analysis of proximal/ distal FMA stat	Acceptable -Modest sample, small groups. -Time since stroke appears to be varied within and bw groups -70 patients declined to take part, why? -Results suggest a lack of clinically meaningful change between or within groups despite reaching significance

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					sig was reached however this was less that 2points in real terms. MRC scores improved by less than one (~0.61) in the DIMT group	
855	H.-Y. Hsu et l (2021). A Tenodesis-Induced-Grip exoskeleton robot (TIGER) for assisting upper extremity functions in stroke patients: a randomized control study. Disability and rehabilitation. 01-Sep.	Single -blinded RCT (Taiwan). Tenodesis induced grip - exoskeletal for hand movement and grip. RCT with pre-treatment (T0), immediate, post treatment (T1)and 12 week follow up assessments (T2). Two evaluators, blinded to the treatment, conducted the evaluation of To,T1,T2 time points. Participants: chronic stroke patients, FMA -UE ranging form 15 to 55, MMSE no lower 24, first ever stroke. Exclusion: Patients with shoulder -hand syndrome, wrist pain, joint contracture, global aphasia. 34 patients randomly allocated to either experiment or control by computer generated random number sealed envelopes. N=17 experimental group. N=17 allocated control. 32 finished the study.	Patients underwent 40min training for 9 weeks at a frequency of 2 sessions per week. Before the session 20 min of regular task - specific motor training in each treatment session, the patients in the experimental and control gp received 20min of TIGER training and regular OT respectively. Tasks chosen: reaching, grasping, releasing an object. Three activities were selected for training during each treatment session that involved an average of 100-200 reps per session. The TIGER training paradigm in the experimental group included a continuous passive mode with wrist flexion/ extension at a frequency of 15 times/min and a	Primary outcome: FMA UE Secondary: Box and Blocks MAL QOM MAS	Patients in the experimental group who received TIGER (20mins) improved more in terms of motor function. A statistically significant bet-group difference was found in the total score and score of FMA-UE (7 points MCID).	**+** MCID changes in the FMA Small sample size. Difficult to generalise

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			functional mode involving gripping pegs with a tenodesis-grip at a frequency of 6 times/min.			
856	S. Jiang et al (2021). Effects of short-term upper limb robot-assisted therapy on the rehabilitation of sub-acute stroke patients. Technology and Health Care. 29: 2. 295-303.	In-patient rehabilitation ward. N=45 people with stroke, aged 35 to 85, less than 30 days since onset, unilateral hemiparesis with arm weakness, Brunnstrom score 3-6. Excluded if severe spasticity (mod Ashworth, MAS, 3-4) Design not clear at outset but participants randomly allocated to conventional rehab (CR) or robotic-assisted therapy (RT).	CR group: neurodevelopmental techniques, functional and muscle strength training. RT group: 'Armeo' spring arm robot. Both groups- 30 mins intervention per day, 5 days per week, for two weeks. RT group also received conventional rehabilitation for same amount of time/days	Fugl Meyer (FMA) and Motricity Index (MI) for motor function, Functional Independence Measure (FIM) and Barthel (BI) for ADL. MAS for spasticity. Baseline (T0), after two weeks training (T1) and at 1 month follow up (T2)	N=23 in RT group; n=22 in CR group. No between groups differences at T1 and T2. Both groups improved significantly on FMA and MI. Improvements in RT group greater than CR group at T1 and T2.	**0** No CONSORT diagram. Numbers screened therefore not clear. Not clear on impact of additional therapy in RT group. No evidence/reporting of blinding of assessors. Authors conclude that RT was effective but was not clear how this conclusion was reached from the presented results .
856	S. Jiang et al (2021). Effects of short-term upper limb robot-assisted therapy on the rehabilitation of sub-acute stroke patients. Technology and Health Care. 29: 2. 295-303.	Inpatient rehab – China. <30 days since stroke. RCT – robot assisted therapy or conventional rehab. N=45	Both groups = conventional rehab for 30 mins, 2x day, 2 weeks. RT group – as for conventional care, + 30 mins, 2x day, 2 weeks (Armeo Spring)	FMA, Motricity Index, MAS, BI.	Both groups improved in motor function (FMA) and ADL (FIM and BI) RT group = greater improvements in motor function and ADL ($p<0.05$).	Low quality. Small sample size. Follow up only at 1m. Groups not dose matched. Unclear if assessors were blinded.
857	J.-H. Kim et al (2021). Efficacy of Electromechanically-Assisted Rehabilitation of Upper Limb Function in Post-Stroke Patients: A	RCT to investigate efficacy of electro-mechanically-assisted rehab of UL function. 48 stroke patients (inclusion criteria: Chronic Stroke Pts confirmed by brain imaging,	Controlled group performed occupational therapist -assisted UL training using conventional method: aim of treatment is to	Primary outcome FMA Secondary outcomes: -Box and Block Purdue Peg Board -Hand grip strength -MAS	-Low quality 33 patients completed all training, 5 Pts in the experimental group and 10 in the control group.	**-** Low quality.

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	Randomized Controlled Study. Journal of rehabilitation medicine. Clinical communications. 4.	fair to good cognitive function, able to sit independently in a wheelchair. Exclusion: pain, spasticity, heart or lung disease, bilateral UL dysfunction) randomly assigned to control and experimental groups.	improve sensory function, joint movement, balance, motor control, task practice, strengthening, goal directed. Experimental: electromechanically using Camillo. Programmes-window cleaning, clay shooting, jumping, fish breeding. Positioning mode chosen by OT according to Pt UL strength. Both groups performed 30min a day, 5 days a week, for 4 weeks, All pts in both groups additional therapy for ADL 30min daily.	MMSE Beck Depressive Inventory EQ -5D-5L -10 item satisfaction questionnaire -Assessments conducted on admission and after intervention.	FMA did not defer between groups. -no statistically significant change or MCID. (however low dose 10 hours on total) Only 33 pts completed outcome measures. High dropout rate (15%).	
857	J.-H. Kim et al (2021). Efficacy of Electromechanically-Assisted Rehabilitation of Upper Limb Function in Post-Stroke Patients: A Randomized Controlled Study. Journal of rehabilitation medicine. Clinical communications. 4.	Investigation of the efficacy of electro mechanically assisted rehab of the UL. Prospective RCT study. 48 Patients between 11 September 2018 and 19 March 2020. Patients were mean duration post stroke of 813.7 days in the control group and up to 342 days post stroke in the experimental group.	Two groups – experimental group underwent electromechanically assisted training using an end effector robot and control group OT training with conventional methods. 30 minutes of intervention per day, five days per week x four weeks.	Fugl-Meyer and secondary outcomes hand function, UL strength, spasticity, mental status and quality of life.	Fugl-Meyer improved in the experimental group but improvement not significantly between groups. Motricity index improved in both groups and was statistically significant. Robot did not demonstrate to be more effective than conventional UL OT.	Poor evidence quality. Different time scales in groups post stroke. Too small sample size. Not clear what conventional UL OT was.

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			33 patients only completed the study.			
858	M. S. Kim et al (2019). Robotic-Assisted Shoulder Rehabilitation Therapy Effectively Improved Poststroke Hemiplegic Shoulder Pain: A Randomized Controlled Trial. Archives of Physical Medicine and Rehabilitation. 100: 6. 1015-1022.	Design: Prospective, single-blind randomized controlled trial investigate the therapeutic effects of a shoulder robot on poststroke hemiplegic shoulder pain. Inpatient setting 38 Participants with hemiplegic shoulder pain patients consecutively recruited and randomly assigned to an intervention or control group.	Robot performed joint mobilization and stretching exercises with patients lying in the supine position Conventional physical therapy directed at improving upper extremity mechanics was performed x2 per day in both groups. In the intervention group, additional robotic-assisted shoulder rehabilitation therapy was administered for 30 minutes per day, 5 times per week for 4 weeks	Pain measures: Visual analog scale (primary outcome) Secondary outcomes: Pain-free passive range of motion of the shoulder joint, Korean version of the Shoulder Disability Questionnaire, ultrasonographic grades The outcomes were at baseline (T0), postintervention (T1), and a 4-week follow-up (T2).	Significant time and group interaction effects were found on the visual analog scale, in the abduction passive range of motion, and on the Shoulder Disability Questionnaire Significantly higher improvements in these outcome measures were observed in the intervention group than in the control group at T1 after post hoc analysis (P<0.05, all). Average VAS score of the intervention group decreased from 6.6 (SD:0.9) to 4.1(0.7) at T1, and this effect was sustained at T2. No significant changes were observed over time in the control group.	Article not assessed for quality as outcome does not fit the question. Outcomes are about pain not arm function This study just demonstrates that a substantial amount of joint mobilisation, that happened to be performed by a robot, was effective in reducing hemiplegic shoulder pain.
859	T. Lencioni et al (2021). A randomized controlled trial on the effects induced by robot-assisted and usual-care rehabilitation on upper	Setting: Unclear Design: RCT Computer randomisation Subjects: N=40 recruited and 32 completed Incl. criteria:	20 sessions with PT 45 mins x 5/7 Robot Group (RG) N=15 5 targets around 20cm circ. Either assistance as	Blinded Ax @ baseline & post intervention FM-UE Instrumental Ax of 2 tasks - object placing - pronation	Although not significant baseline differences: FM-UE RG=45 & UCG=21 Age RG=68 & UCG=59 Time RG=7.8 & UCG5.8	- Low quality. No ITT No discussion of those not analysed

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	limb muscle synergies in post-stroke subjects. Scientific reports. 11: 1. 5323	18+ NIHSS UL 1-3 (movement but impaired) FM-UE >6 (out of 66) Excl. criteria: MMSE<20.	needed or resistive modes – chosen by PT each session based on ability – no more details offered. Usual Care Group (UCG) N=17. Broadly described	Surface electrodes for muscle synergies.	That means that usual care were younger & more acute but with more impaired UL's FM-UE: "all pts showed an improvement, regardless of treatment" but not stat sig or listed in article.	Although not stat sig differences – baseline ?? Numbers calculated for "demonstration of concept stage" – is this more a feasibility study No mention of the contribution of different modes how many used resistance v's assistance Despite criteria being open to FMUE>6, all participants were able to complete tasks independently at baseline.
859	T. Lencioni et al (2021). 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. 11: 1. 5323	Conducted in Italy (data from the larger multicentre MOSE RCT was used) However only one site "Centre 2" data was used for this evaluation n=40 Chronic stroke Single blind Compared usual care group (UCG) vs Robot Group (RG) and some analysis with Healthy subjects (HS). This paper provides little information on healthy subjects.	Both groups: 20 sessions, 45min each, 5/7 delivered by physio RG: Arm supported and reaching for targets UCG: passive/active movement and task-oriented exercises.	FMA UL Kinematics captured during "Object placing and forearm pronation task" Assessed prior to intervention commencement and immediately following .	Per protocol analysis meant final comparison was (RG: n=15) vs (UCG: n=17) Both groups showed modest FMA improvement RG:7.1 points vs UCG:55 The RG group improved on proximal kinematic measurements and axial to proximal synergies UCG had greater preservation of smoothness of movement and shoulder angle	Unacceptable. It seems somewhat dramatic to consider a Nature publication unacceptable, however the two groups compared in this study appear insuperably clinically different at baseline (FMA scores were ~24 points different between groups see Table 1). Also of note yet less concerning was a ~11 yr age difference between groups.

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						The authors offer statistical baseline comparison and negative p values, however this not appropriate use of an inferential test (see here or consort statement). Did not feel confident groups were similar at baseline.
860	K. Lo et al (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.	Setting: In & outpatient (not community) Design: SR Subjects: 5 studies n=213 (4 limited to UL & 1 both UL & LL) n=20,23,27,50 & 93. Incl. criteria: Trials of adult stroke survivors (18+) comparing economic outcomes for robotic devices & usual care. Not limited to chronicity or severity English language Sub groups: Mild/mod v's severe Acute/sub v's chronic	Intervention arm: All dose matched against routine care. Training varied from 20-300 hrs. Ranged from adjunct to robotics alone, from single robotic to 4 stations over 2 hours combination of robotics and non-assistive mechanical devices.	Cost minimization Head-to-head comparison data for other outcomes not included Cost effectiveness Cost per unit of effect (FMUE or UL motricity) Cost utility Relative costs for QUALY Cost benefit Relative costs to achieving a unit of benefit during rehabilitation phase - therefore no social or follow up savings included (monetary).	2 trials used circuits that included robotics (therefore not reflecting costs of either or) 1 trial was completed in Mexico where labour costs are low and had sig younger robotic group Suggests that robotic therapy may have better economic outcomes for those with more severe impairments and those more chronic "Hospital providers could increase the number of patients treated during a robotic therapy session and minimize the involvement of therapists as far as possible, while still maintaining patient safety." JBI Grade B recommendation. I	Low quality Struggled with data extraction Small no. of studies and small sizes Heterogenous samples / designs / interventions / robotic device used Costs dependent on context (labour and health system) Despite collecting clinical outcome measures no mention Generated an adapted ranking methodology specifically for this review Health outcomes scored as better / equal / poorer – but fails to include clinical info to support .

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					would strongly argue this review offers insufficient evidence to support the recommendations it makes.	
861	J. Mehrholz 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. 2018: 9. CD006876.	Systematic review of RCT and randomised cross-over trials of electromechanical and robot-assisted arm training after stroke. Participants over 18 years old with stroke. Included participants with stroke any time from onset initially, but later analysed according to acute/subacute (first three months) and chronic (more than three months).	Compared electromechanical and robot-assisted arm training for recovery of arm function with any other intervention (other device, other rehab, placebo or no treatment) in people with stroke electromechanical and robot-assisted arm training considered together, not individually	Primary outcome=ADL Secondary outcome= impairments 'such as motor function' (Fugl Meyer) and strength (Motricity Index). If these two not used, other scales were considered acceptable. Meta-analysis compared electro-mechanical and robot-assisted versus placebo and electro-mechanical and robot-assisted with physiotherapy versus physiotherapy alone.	4803 records identified. 45 trials with a total of 1615 participants, included in the analysis. Most were in rehabilitation facilities in the USA. Participants 21 to 80 years. Study duration varied two weeks to 12 weeks. Most interventions were five days per week, intensity ranged 20 minutes as high as 105 minutes. Study quality mainly high. Electromechanical and robot-assisted arm training vs all other intervention improved ADL (pooled SMD 0.31 (95% CI 0.09 to 0.52, P = 0.005, level of heterogeneity I2 = 59%). When comparing acute and chronic phases, intervention improved ADL in acute (SMD random-effects model 0.40 (95% CI 0.10 to 0.70, P = 0.009, level of heterogeneity I2 = 63%) but not chronic (SMD	**++**

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					random- effects model 0.19 (95% CI -0.13 to 0.50, P = 0.24 , level of heterogeneity I2 = 54%). Improvements also found in muscle strength and arm function at end of intervention phase. Conclusion is intervention slightly improves ADL, muscle strength and arm function. Different amounts of reps or arm training were NOT analysed here nor was cost of the device/intervention considered. Clinically meaningful change not clear. Consider also that most studies carried out in USA.	
861	J. Mehrholz 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. 2018: 9. CD006876.	SR and meta-analysis. GRADE used to assess quality of studies.	Included RCTs comparing electromechanical and robot assisted arm training with other therapy, no therapy or placebo. Also assessed acceptability and safety.	Measures of ADL, arm function and muscle strength.	5 trials (1619 participants included) EM and RAT improved ADLs (high quality evidence) arm function (high quality evidence_ and strength (high quality) “people after stroke who receive electromechanical or robot-assisted arm	**++** Thorough review following Cochrane standards. Studies included in the review were generally of high quality. Authors advise caution with interpretation as there were variations in the trials in terms of

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					training are more likely to show improvement in their activities of daily living, arm function, and muscle strength of the paretic arm, and we rated the quality of evidence as high".	intervention type, intensity, duration etc.
862	J. Mehrholz 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 and Rehabilitation. 17: 1. 83. 83.	Systematic review of RCT trials with network analysis. 55 RCT trials including 2654 patients with stroke.(Based in Germany Department of public health) PROSPERO database. PRISMA criteria. Inclusion studies had to measure at least pre-stated outcomes of ADL hand/arm function. Two independent reviewers applied selection criteria	Data collection: Two independent reviewers applied selection criteria (Defined categories of different types of robotic arm-training, discussed possible robotic approaches and reached a consensus. -Defined conventional arm training as any other control intervention used to improve ADL. -Any differences between reviewers a 3rd reviewer would be used if necessary. Categories included: -Armeo spring -RA-shoulder -Therapy -REJOYCE Robotic MIT-Manus -Inmotion	Primary outcome: Barthel Index, FIM for ADL Primary outcome of hand - arm function prioritised reports of FMA-UE. If scale not available accepted Wolf Motor Function Test Secondary outcome of hand-arm:strength -grip strength and equivalent scales.	Systematic search found 6744 matches. Excluded irrelevant. 55 RCT met selection criteria. Number of participants included in the trials ranged from 8 to 770 with a mean of 24 participants. For primary outcome of ADL none of the intervention categories significantly improved ADL measures. No Systematic differences in any outcomes between different approaches to hand -arm training after stroke. These findings currently no clear evidence to support the selection of specific types of robotic device tools to promote hand -arm recovery.	**+** Outcomes measures of Barthel and FIM would not demonstrate change in use of arm of hand function in ADL. More appropriate measures would CAHAI or Wolf Motor function Test.

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862	J. Mehrholz 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 and Rehabilitation. 17: 1. 83.	Systematic review of randomized controlled trials with network analysis to assess the relative effectiveness of the various types of electromechanical-assisted arm devices and approaches. 55 RCT included, 2654 patient with Stroke. Study set in Germany	Conventional arm training as reference category and compared it with different intervention categories of electromechanical-assisted arm training. Indirect comparison between types of robotic devices.	Primary outcome – Fugl-Meyer. Secondary outcome – Motricity index, grip strength and equivalent scales and versions.	Outcomes of robotic assisted arm training were comparable with conventional therapy. No one robotic device was better or worse than the other.	+ Inconsistencies in the description of complex interventions by trial authors. Findings limited to pre-defined categories of robotic approaches.
863	L. Moggio 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. 01-Dec.	SR and MA 5 RCTs, n=149	End effectors (EE) or Exoskeleton (EXO) devices) for motor recovery of finger and hand motor impairments vs control. RT = EE + EXO.	Motricity Index (MI) Quick DASH FM-UE RT vs control EE vs EXO vs control	MI: RT stat sig increased hand fx (Effect Size (ES) 9.47, CI:3.91-15.03, p<0.05) QuickDASH: RT sig reduced impairments (ES: -6.71, CI: -9.17—4.25, p<0.05) FM-UE: RT improved UL (ES3, CI:1-97-4.04, p<0.05). EXO results in highest probability of finger and hand recovery, then EE, then control.	+ Very small number of studies and sample size OMs used were comprehensive UL OMs not specific to finger and hand.
863	L. Moggio et al (2021). Exoskeleton versus end-effector robot-assisted therapy for finger-hand motor recovery in stroke survivors: systematic	A systematic review and meta-analysis to determine whether end effector robot therapy or exoskeleton robot therapy is better for finger hand motor recovery in	Robot therapy focusing on the hand Exoskeleton in which each degree of freedom is aligned with the affected joint, following	Motricity index (MI) - assesses shoulder abduction, elbow flexion, and pinches grip.	Only 5 RTC were included and these had small samples sizes, total 149 subjects. One of the 5 studies was assessed as poor quality.	+ Forest plots show clear effects in the better quality studies. The effect sizes were high for outcomes:

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	review and meta-analysis. Topics in stroke rehabilitation. 01-Dec.	stroke patients. There are important differences in the design of the two robots for hand treatments. Because it would be uncommon for these two types of robot therapy to be directly compared in a trial the authors have used a method that allows indirect comparison called surface under the cumulative ranking analysis (SUCRA). Inclusion criteria for trials: · RCTs with finger hand robot assisted therapy · Adults stroke patients <12 months post onset of stroke · Presence of upper limb functional limitation involving wrist and fingers English full text	anatomy, to allow the hand to be used with the palm free from encumbrance and end effectors robots which may position the hand for a task but may constrain its use due to the design of the robot arm and its attachment Control group 'conventional therapy'	Quickdash - questionnaire allowed to estimate the entire upper extremity function and subdivided into an 11-item (abilities and symptoms) and an 8-item optional high-performance sport/music or work modules. FMA UE - sensorimotor recovery of the upper limb (coordination, movement, and reflex) in stroke patients, with particular attention to the hand and wrist section	MI significant improvement ($p < .05$) in robotic group vs control group (effect size, ES: 9.47; confidence interval, CI: 3.91, 15.03). QuickDASH reported a significant reduction in disability ($p < .05$) in EXO group (ES: −6.71; CI: −9.17, −4.25). FMAUE significant improvement ($p < .05$) in the EE group (ES:3; CI:1.97, 4.04). SUCRA analysis of MI demonstrated that robotic interventions are more likely to be the best option for motor recovery (97.3% of probability EXO; 48.3% EE; 4.4% control).	Motricity index and Quickdash, low for FMA. According to the SUCRA exoskeletons ranked higher than the end effector robot. However, the study included only five studies, all with low numbers of participants I would treat this with caution. Also the measure with the highest effect size (9.47) was Motricity index and that is the least sensitive for dexterity. Quickdash had good effect size (-6.71); the FMA which focussed on hand and fingers had the low effect size (3.00), Further studies are needed to achieve more confidence in findings.
864	G. Morone et al (2021). Systematic review of guidelines to identify recommendations for upper limb robotic rehabilitation after stroke. European journal of physical and rehabilitation medicine. 57: 2. 238-245.	Criteria: English language Any guideline recommendation for UL robotic rehab in adults with stroke between 2010 & 2020 1324 records à8 matching criteria (Incl. RCP 2016)	AGREE-II instrument was used to appraise the methodological quality of guidelines across 6 domains: scope and purpose, stakeholder involvement, rigor of development, clarity and presentation, applicability & editorial independence. It uses a 7-point agreement	Methodological heterogeneity ++ No agreement on outcome measures. Only 4 guidelines specific to rehabilitation.	The patient subgroup that could benefit from robotic device is not clarified throughout the guidelines. Moreover, the optimal time window and frequency are not clarified Guidelines often do not specify the type of recommended robotic device and its specificity	**+** But does not provide any tangible info for the question at hand.

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			scale from 1 (strongly disagree) to 7 (strongly agree) for 23 items.		for proximal or distal upper limb use. Furthermore, the optimal dose (number of repetition and time of therapy), frequency and duration of the robotic rehabilitation treatment is not taken into account.	
864	G. Morone et al (2021). Systematic review of guidelines to identify recommendations for upper limb robotic rehabilitation after stroke. European journal of physical and rehabilitation medicine. 57: 2. 238-245.	SR of guidelines relating to robotics for UL rehab post stroke – aimed to determine the quality, scope and consistency of clinical practice guidelines. Search from Jan 2010-Jan 2020. 4 independent reviewers. Used AGREE framework to extract data.	Included guidelines (defined as a set of recommendations based on evidence appraisal and consensus). Search focussed on guidelines referring to stroke rehab and considering the use of robotics for UL rehab.	AGREE II criteria used to evaluate quality of the guideline.	1324 papers screened. 8 eligible guidelines included; from 6 countries/regions. Quality ranged from 66-91% (cut off value reported as 70%) Robot assisted therapy generally recommended within the included guidelines. Exact characteristics of patients who could benefit, and optimal timing of treatment unknown.	Good quality review, well described, appropriate criteria and tools used for standardisation.
865	Olczak et al (2022). The Use of ArmeoSpring Device to Assess the Effect of Trunk Stabilization Exercises on the Functional Capabilities of the Upper Limb-An Observational	Randomised, double-blind study of n=60 participants after stroke. People 5-7 weeks after stroke, poor trunk control (Trunk Control test TCT 48-61), could move upper limb (FMA-UE 43-49), aged 35-85. Rehabilitation clinic	Study group (SG) had physiotherapy based on Bobath/NDT trunk training. Control group (CG) 'classic exercises' and exercised in a suspension system, progressed to active and resisted exercises.	Evaluation games on Armeo device, including reaction time	SG demonstrated significant improvements for four of the evaluation games.	**0**

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	Study of Patients after Stroke. Sensors (Basel, Switzerland) 22: 12.		Treatment for 120 minutes for ten days. ARMEO device used for assessment/evaluation not intervention- report states used in 'evaluation games.'			
866	R. Ranzani et al (2020). Neurocognitive robot-assisted rehabilitation of hand function: A randomized control trial on motor recovery in subacute stroke. Journal of NeuroEngineering and Rehabilitation. 17: 1. 115.	Parallel group RCT of n=33 people with stroke in previous six weeks receiving either conventional (CG) or robot assisted (RG)neurocognitive therapy. Rehabilitation clinic, Switzerland.	Neurocognitive therapy approach for both intervention and control- exploring objects and discriminating properties and differences. Intervention group used haptic robot. Control group was conventional approach. Seven exercises available to both groups, seventh exercise in control group was texture identification whereas in robot-assisted group was vibratory cueing for pro and supination activity. Each session used 2 or 3 exercises, 30 or 45 minutes for conventional and in robotic-assisted group, 45 minutes of therapy included 3 exercises, max 15 minutes each one. Dose-matched.	Evaluated before and after intervention (T0 and T1) and at 8 week (T2) and 32 week (T3) follow up. Primary outcome change from baseline to outcome on FMA-UE. Wide ranging secondary outcomes including motor, sensory and cognitive scales, plus intensity and acceptance of robotic therapy. Used equivalence analysis of FMA to explore if therapy with haptic device could lead to equivalent sensorimotor recovery compared to dose matching conventional therapy.	33 people randomised, 17 to RG and 16 to CG. 6 people did not complete or withdrew, modified ITT analysis used. Change in FMA in RG considered 'non-inferior' to CG. Both groups improved, RG by 7.14 points and CG by 6.85 points at T1. No change between groups on secondary measures. Approach acceptable to patients.	**+**
866	R. Ranzani et al (2020). Neurocognitive robot-assisted rehabilitation of	Parallel group RCT. Sub acute stroke. Inpatient unit in Switzerland.	Compared conventional rehab to robot assisted neurocognitive hand	Primary - FMA-UE	33 subjects randomised; 6 lost to follow up (similar between groups)	**++**

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	hand function: A randomized control trial on motor recovery in subacute stroke. Journal of NeuroEngineering and Rehabilitation. 17: 1. 115.	33 participants – 14 in RAT group, 13 in conventional. >6 weeks post stroke; 18-90yo, motor arm deficit > or = 1 on NIHSS. Excluded severe aphasia, severe cognitive impairment, pain Assessor blind. All participants received 3 neurocognitive sessions per day focussing on hand function (2 x 45 mins and 1 x 30 mins) – described in paper (sensorimotor exercises) In the robot assisted group, one of those sessions was replaced with robot assisted therapy.	therapy using a haptic device. 15 x 45 min sessions, over 4 weeks. Aimed to establish equivalence.	Secondary – Box and Block; MAS; Nottingham Sensory Assessment; MMSE; Albert Teat (spatial neglect); Frontal Assessment Battery. Also recorded therapy intensity to verify dose matching. Follow up at end of intervention, week 8 and week 32. Questionnaires – user acceptance.	Both groups improved above MCID for FM-UE. Motor recovery in the Robot assisted group was non-inferior to control on FMA-UE. Task repetitions similar in both groups – although less variable in RAT. RAT found to be acceptable to patients.	Not clearly labelled as feasibility until discussion, but this was a feasibility trial. Small number of participants, powered to detect non-interiority.
867	O. Remy-Neris et al (2021). Additional, Mechanized Upper Limb Self-Rehabilitation in Patients with Subacute Stroke: The REM-AVC Randomized Trial. Stroke. 1938-1947.	Phase III, parallel concealed allocation, RCT multicentre trial (21 rehab centres in France) with 12 month follow up. TIDieR checklist used to report this study. Participants: inpatients duration of the trail. Inclusion: 18 -81 years diagnosis of haemorrhagic or ischemic stroke 3 weeks to 3 months. FMA UE score 10 to 40 points. Exclusion criteria shoulder pain, fatigue, visual impairment that would	This study involved usual rehab for all participants followed by an additional daily hour of self-rehabilitation (2 x 30 minute sessions) over 4 weeks consisting of either gravity -supported using exoskeleton Exo group. Or basic stretching and active exercise (control group). 215 participants randomly allocated to	Outcomes measured baseline, end of intervention, 3 months, 6 months and 12 months. Therapists were blinded to group allocation. Primary outcome: FMA UE Secondary: -Change in sensorimotor impairment -Change in severity of shoulder pain at rest and during active and passive movements Change in spasticity MAS	No between -group difference in the mean FMA UE Secondary outcomes: No between group differences in any of the Neutral outcome of this study. RCT did not support the hypothesis that additional self- rehab performed with gravity supporting would	Low sample size (Low quality Low dose of therapy (10 hours over 4 weeks)

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		prevent participation, inability to sit independently.	the Exo-group (107) or the control (108). Patients enrolled/ allocated physician at each site via secure web based data entry system. Therapist received training in the use of devices and in the use of self-rehab during a 2- day training programme. Sessions recorded attendance and duration.	Change in FIM, ARAT, EuroQol 5 Between-group differences in cost utility -Comparison of the participants'' perception of their group's exercise intervention (5 custom made questions)	improve FMA-UE score more than basic stretching and active exercises.	
867	O. Remy-Neris et al (2021). Additional, Mechanized Upper Limb Self-Rehabilitation in Patients with Subacute Stroke: The REM-AVC Randomized Trial. Stroke. 1938-1947.	Comparison of self rehabilitation using a mechanized device v's a control group with self-exercises on upper extremity impairment. RCT, multi-centre trial set in France. All participants were in an inpatient unit, aged 18 to 80 years and 3 weeks to 3 months post stroke.	Participants with a Fugl-Meyer 10 to 40 points were ramdomized to the exo or control group. Both groups participate in two 30 minute self rehabilitation sessions five days a week for four weeks in addition to usual rehabilitation. Exo group performed games based exercises using a gravity supported mechanical exoskeleton and the control group completed stretching plus basic active exercises. Measures taken at baseline, four weeks and after 12 months.	Fugl-Meyer – baseline and four weeks. Secondary measures: VAS for pain, Modified Ashworth, FIM, ARAT, Euro Q0L and patients perception of their group exercise intervention.	Did not support hypothesis that additional self rehab with a gravity assisted device improve impairment more than basic stretching and active exercises in the subacute phase of stroke patients with moderate-severe impairment in UL function.	**+** quality of study. Recruitment of study very long. Measurement rehab was not evaluated.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
868	S. G. Rozevink 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 and rehabilitation. Assistive technology. Jan-14.	SR and MA 17 RCTs Chronic and subacute stroke	Task specific training using assistive devices which are robotic or non-robotic (TTAA) vs task specific usual care (UC) on UL fx Assistive devices included robotic and non-robotic	FM-UE Subacute FE-UE Chronic	FM-UE Subacute: TTAA sig better than UC (SDM: 1.24, 95% CI:0.2-2.28) but finding based on only three studies. FM-UE Chronic: no dif difference (SMD: 0.08 95% CI:-0.28-0.45)	**+** Acceptable.
868	S. G. Rozevink 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 and rehabilitation. Assistive technology. Jan-14.	This is a systematic review and analysis of Effectiveness of task-specific training using assistive devices and task-specific usual care on upper limb performance after stroke. One of the difficulties the authors faced in judging articles for inclusion was determining if the programmes and devices fulfilled their task specific criteria. The authors tried to separate out studies with sub-acute and chronic participants. Also they were only able to include a subset of studies in the meta-analysis and these all used FMA as outcomes.	-Participants were trained in a task specific way satisfying at least 4 of 7 criteria for being task specific using an assistive device in the experiment group and without a device in the control group. -Device either supported weight of the limb or supported joint movement. So did not have to be a robot	Multiple AMAT: arm motor activity test; ARAT: action research arm test; B&B: box and block test; BI: Barthel index; BL: bilateral; CAHAI-9 ¼ Chedoke arm and hand inventory; CG: control group; CMSA-H: Meta analysis carried out only for studies using FMA UE. Many other assessments were used in the studies included: Chedoke McMaster stroke assessment-hand; COPM: Canadian occupational performance measure; FAS: functional ability scale; FIM: functional	17 studies were included, involving 383 participants. only 3 studies, (101 patients) of the subacute phase (≤ 6months post onset) were included in meta-analysis, and 8 studies of 282 chronic patients (>6 months). Various quality complicated to see assessment. Sub-acute results Task-specific training using assistive arm devices was more effective than task specific usual care, in reducing the upper limb impairment in sub-acute	**+** A difficult study to assess, many different study designs were included, Not all studies used a robot, other devices were acceptable in the review, Only 3 studies were included in the meta-analysis of sub-acute patients.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		Criteria for inclusion of articles: -Participants were adult stroke with hemiplegia - Multiple designs included – piot, uncontrolled, crossover, RCT -Participants were trained in a task specific way satisfying at least 4 of 7 criteria for being task specific using an assistive device in the experiment group and without a device in the control group. -Device either supported weight of the limb or supported joint movement. -One of the outcome measures was an arm function test -Written in English or dutch -Min no. of participants =10 Published as a full paper		independence measure; FMA-UE: Fugl-Meyer assessment-upper extremity; FTHUE: functional test of hemiparetic upper extremity; MAL: motor activity log (AoU: amount of use; QoM: quality of movement); MAS: motor assessment scale; MSS: motor status scale (sh: shoulder; ha: hand); NHP: nine hole peg test; Rancho: Rancho Los amigos functional test of upper extremity function; SIS: stroke impact scale; SM: sensorimotor; UL: unilateral; WMFT: Wolf motor function test. 3D-DHD: three-dimensional dynamic hand device;	patients, although findings were based on only three studies. Std mean diff 1.24 95%CI 0.20,2.28 – way below the minimal clinically important difference of 9 points for the population In the chronic phase, task specific training using assistive devices and task specific usual care showed similar effectiveness. No differences between the two types of training were found at the follow-up measurements.	
869	S. Straudi et al (2020). Effects of a Robot-Assisted Arm Training Plus Hand Functional Electrical Stimulation on Recovery After Stroke: A Randomized Clinical Trial. Archives of Physical Medicine and Rehabilitation. 101: 2. 309-316.	Setting: Inpatient rehab @ University Hospital Design: Single-blinded, randomised controlled trial Subjects: n=40 Criteria: Ischaemic stroke <8/52 with UL impairment FMA-UE 11-55 18-80 Single stroke <21MMSE >7/10 Pain VAS	Experiment: (n=20) 30 sessions (5 per week) of Robot Assisted Therapy & hand functional electrical stimulation (RAT & FES) 40 mins FES followed by 60 mins RAT. Control: (n=20) Time matched intensive therapy – 100 mins of	Both groups significantly improved all outcome measures except for spasticity without differences between groups. Moderate and early rehabilitation subgroups achieved the greatest clinical improvements after rehabilitation compared	Patients with moderate impairment and presence of MEPs who underwent early rehabilitation (<30d post stroke) demonstrated the greatest clinical improvements. However, this was significantly influenced by the earlier enrolment	**+** Combination of FES and RAT therefore unable to attribute improvements to RAT alone. Also – Control group was acknowledged as receiving more intense (if poorly described) therapy that "routine" – in effect a comparative head-to-head rather than a true control group comparison.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		Block randomisation via external website	ex's, sensory & functional activities. Outcome measures: Primary = FMA-UE Secondary = Motor function (Box & block and Wolf Motor Function test)) UL spasticity (MAS) ADL's (BI). Motor Evoked Potentials (MEPs) recorded at baseline. Ax by blinded: T0 (baseline) T1 (3/52) T2 (End of intervention) T3 (6/21).	with the severe and late rehabilitation subgroups.	those with less severely impaired UL's.	Points towards 100 mins of 5/7 UL focussed rehab for 6/52 as being influential.
869	S. Straudi et al (2020). Effects of a Robot-Assisted Arm Training Plus Hand Functional Electrical Stimulation on Recovery After Stroke: A Randomized Clinical Trial. Archives of Physical Medicine and Rehabilitation. 101: 2. 309-316.	RCT based in Italy. n=40 Compared Robot assisted training (RAT+FES) vs same dose conventional therapy (CT) Single blind, prospective Recorded MEPs at baseline FMA baseline between >11 and >55 First ever stroke <8weeks	Both groups: 5/7 over 6wk RAT+FES: 1 hour and 40 minutes -40-minute session of hand FES, After FES training, patients received 60 minutes of RAT CT: The control group received the same time of conventional arm	FMA UL - primary WMFT BBT MAS Repeated measures at (blinded Ax): T0 – baseline T1 – 3 weeks T2 – 6 weeks (end of treatment) T3 – 6months	Researchers also split and analysed patients by subgroups without offering citations for the arbitrary definitions: ≤30 days since stroke Vs >30 days since stroke And ≤21 points on FMA Vs >21 points on FMA Both groups RATFES and CT improved on all outcomes except MAS.	**+** This was a well conducted study. Greater detail on the statistical analysis would have been helpful. Of note. A linear regression was used. The groups were small, and I had some concern that baseline variances may have been uneven and the underlying data not normally distributed (I acknowledge groups were similar at baseline). I saw

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			therapy (100 minutes). Specific exercises for the affected upper limb included active, passive, and sensory exercises or functional tasks		The presence of MEPs was associated with greater improvement. They suggest that the in the presence of MEPs and same level of arm impairment RATFES may be superior	no mention of efforts to counteract multiple comparisons (eg Bonferroni) though this may not have been needed.
870	T. Takebayashi et al (2022). Robot-Assisted Training as Self-Training for Upper-Limb Hemiplegia in Chronic Stroke: A Randomized Controlled Trial. Stroke. 53: 7. 2182-2191.	Multicentre RCT, n=161 Chronic stroke survivors Outpatient setting FM <44	(1) Conventional self-training plus conventional therapy (CG) (2) robotic self-training plus conventional therapy (RT) (3) robotic self-training plus CIMT (Movement Therapy (MT)) 1 hour, 3/7, 10/52.	Primary OM: FM-UE Secondary OM: Motor activity log (MAL) amount of use and quality of mvt, FM shld/elbow/forearm, wrist, fingers, ARAT MI MAS ROM of shld, elbow, forearm, wrist and fingers Stroke impact scale.	No statistically significant difference in FM-UE between groups RT showed statistically significant difference in FM shoulder/elbow/forearm compared to CG (p=0.037). MAL amount of use was higher for MT than CG (p=0.047) .	**+** Needed 39 per group for adequate power but only 37 in control group.
871	T. Takebayashi et al (2022). Impact of the robotic-assistance level on upper extremity function in stroke patients receiving adjunct robotic rehabilitation: sub-analysis of a randomized clinical trial. Journal of NeuroEngineering and Rehabilitation.	Secondary analysis of multi-centre RCT ID60. Investigated impact of level of assistance provided by robot. Sub-analysis of n=30 people with sub-acute stroke, mild-severe arm weakness from Robotic therapy arm of previous trial. People 20-80 years, 4-8 weeks from onset first stroke, upper limb	Robotic therapy 40mins/day over 6 week study duration, in addition to conventional therapy (described in previous study, not detailed fully here). For this study, subjects classified based on cluster analysis using number of times each of five assistance modes were used on the robotic	Fugl Meyer, FMA-UE, and Wolf Motor Function test, WMFT.	Severe to moderate weakness group receving considerable assistance showed more significant improvement on FMA-proximal, WMFT-PT and WMFT-FAS than those receiving minimal assistance. But for those with mild-moderate weakness, findings were improved UE performance and	Secondary analysis.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	19: 1. 25.	weakness Brunnstrom score III or IV. Rehabilitation hospitals in Japan.	device, so intervention group considered to be those receiving 'considerable' robotic assistance and control group those with 'minimal' robotic assistance. Two groups sub-categorised for analysis- those with severe to moderate UE weakness (FMA less than 30) and those with moderate to mild weakness (FMA greater than or equal to 30).		weakness in minimally assisted group. No difference on group/severity interaction.	
871	T. Takebayashi et al (2022). Impact of the robotic-assistance level on upper extremity function in stroke patients receiving adjunct robotic rehabilitation: sub-analysis of a randomized clinical trial. Journal of NeuroEngineering and Rehabilitation. 19: 1. 25.	Exploratory sub-analysis of data from an RCT – to investigate whether assistance levels offered by the robotic device affect outcomes. 30 sub acute stroke survivors with mild-severe UE hemiplegia; randomly assigned in RCT to use ReoGo system or conventional therapy. Based in inpatient rehab in Japan.	Patients divided into two groups- high or low assistance. Sub-groups also sub-categorised according to baseline impairment using FM-UE.	FM-UE WMFT Blinded assessors.	Amount of robotic assistance is likely to impact outcomes from RAT; severity of UE paralysis also a factor in outcomes. i.e those with greater weakness benefit from higher robotic assistance; those with less weakness benefit from lower robotic assistance.	**+**
872	S. Taravati et al (2022). Evaluation of an upper limb robotic rehabilitation program on motor functions,	Single blind RCT. Based in Turkey To find whether conventional PT combined with robot assisted therapy is	Robot rehab was arranged to be 30–45 min, 5 days per week for 4 weeks.	All patients were assessed at the beginning of therapy and the end of 4th week with Brunnstrom stages of motor recovery,	No Statistically significant difference found between groups.	**+**

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	quality of life, cognition, and emotional status in patients with stroke: a randomized controlled study. Neurological Sciences. 43: 2. 1177-1188.	superior to conventional PT alone. 37 single stroke duration 4 to 30 months. Recruited April 2016 and April 2019 . 16 in mini -mental test, UE Brunnstrom stage 2 or higher. 67 patient s eligibility. 53 pts met criteria -8 pts refused. Pts randomized into 2 groups (Robotic rehabilitation group- n:22, Control group n:23) 17 pts in the Robotic rehab and 20 in the control completed the study.	Control group received only conventional rehab carried out by PT ROM exercises, muscle strengthening, balance, mobility, exercises to enhance ADL, Bobath technique sitting and standing, transfers, proprioceptive exercises, balance exercises, OT (60mins daily) and cog rehab.	Hand grip strength, MAS, FIM, Nottingham extended ADP, FMA, Purdue Peg board, Minnesota manual dexterity test. Other outcome measures: Montreal Cognitive Assessment (MoCA) and Center for Epidemiological Studies Depression Scale (CES- D). Stroke Specifc Quality of Life Scale (SS-QOL).	FMA, FIM, - no significant difference.	
872	S. Taravati et al (2022). 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. 43: 2. 1177-1188.	RCT study looking at if robotic therapy in addition to a conventional rehab programme affects quality of life, motor function, cognition and emotional status. 37 stroke patients between April 2016 – April 2019. Single stroke 4-30 months post stroke. Study set in Turkey.	Two groups: Robotic group (17) (Reogo Motorika upper extremity rehab system) and conventional therapy. Control group (20) – conventional therapy only. Conventional therapy was physiotherapy, OT five days a week for four weeks. Psychology twice a week for four weeks.	Brunnstom stages of motor recovery. Fugl Meyer Handgrip strength, Purdue peg test, Minnesota manual dexterity test, modified Ashworth, FIM, SS-QOL, Nottingham extended ADL, MOCA and center for epidemiological studies depression scale (CES-D).	Improvements in motor, spasticity, general function, ADL, Cognitive were better in the robotic group compared to the control but not statistically different. Improvements in the CES-D in the robotic group better than control (statistically significant).	**+** Limited numbers in the study. Big difference in time since stroke in the group. Only looked at benefit after four weeks not in the longer term.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			Robotic group – 30-45 mins of robotics five days per week for four weeks.			
873	J. Wu et al (2021). Robot-Assisted Therapy for Upper Extremity Motor Impairment After Stroke: A Systematic Review and Meta-Analysis. Physical therapy. 101: 4.	SR and MA 41 RCTs, n=1916 Stroke survivors .	Robotic assisted therapy (RT) vs usual care for improving UE motor impairment.	FM-UE Unilat vs bilat Type of device: End effectors vs exoskeleton Stage of stroke Baseline motor impairment Trained part .	M-UE: RT sig improved UE with small effect size (Hedges g=0.25, 95%CI 0.11-0.38; p<0.001) immediately after training but results not maintained at follow up. Unilateral RT was superior to usual care (Hedges g=0.32 95% CI: 0.15-0.50; p<0.001). Bilat RT and combined bilat and unilat RT not superior to usual care. End effector device not exoskeleton was superior to usual control (Hedges g0.22, 95% CI: 0.09-0.36) RT was only superior for those with late subacute or chronic stroke (Hedges g 0.33, 95% CI: 0.16-0.50) compared to acute stroke (< 3 months) RT was superior for those with mod to severe motor impairment (Hedges	**++** Large sample size compared to other SRs.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					g=0.27, 95%CI 0.08-0.46, p=0.004) but not mild to moderate impairment Both training shld/elbow and forearm/wrist/hand were superior to usual care.	
873	J. Wu et al (2021). Robot-Assisted Therapy for Upper Extremity Motor Impairment After Stroke: A Systematic Review and Meta-Analysis. Physical therapy. 101: 4.	A large and very relevant Systematic literature review and meta -analysis review Questions: (1) Does Robot-assisted therapy (RT) have a superior effect on improvement of upper extremity motor impairment in stroke patients compared with the conventional, therapist-led rehabilitation training, in short-term (immediately after intervention) or long-term (follow-up) outcomes? (2) Is there any difference in effects between Bilateral RT and Unilateral RT? (3) Could the patient characteristics such as stroke stage or the baseline level of upper extremity motor impairment measured with the FMA-UE scores influence the effect size associated with the treatment? (4) could the type of robot device (e.g., end effector or exoskeleton) influence the	Robot assisted therapy using either end effector or exoskeleton robot And either unilateral or bilateral training robot assisted programmes Could involve whole upper extremity, or shoulder elbow or wrist/hand	FMA- UE	Forty-one RCTs, 1916 stroke patients included. Question 1 Compared with dose-matched conventional rehabilitation, RT significantly improved the FMA with a small effect size (Hedges g = 0.25; 95% CI, 0.11-0.38; I2 = 45.9%). Question 2 Subgroup analysis effects of unilateral RT, but not that of bilateral RT, were superior to conventional rehabilitation with small effect size (Hedges g = 0.32; 95% CI, 0.15-0.50; I2 = 55.9%). Question 3 stroke stage: the between-group difference (ie, RT vs convention rehabilitation) was significant only for people with late	**++** This is a very good and substantial review and meta-analysis that directly answers question 30, and goes beyond it because the authors probed other questions to determine what kind of robot-assisted therapy was effective and for which patients. The PRISMA procedure was followed and statistical treatment of the data was excellent. Much of the detail evidencing the robust research process in given in the supplementary information file Findings are valuable for the new guidelines. It directly answers question 30, other sub-questions to determine what kind of robot-assisted

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		effect sizes associated with the treatment? Inclusion criteria for articles: (1) RCTs (crossover or parallel design); (2) Population - adults with unilateral hemispheric stroke; (3) intervention used a robot-assisted device (4) In at least 1 control group participants received dose-matched conventional PT or OT led by therapists (experimental and control groups had equal treatment times) (5) outcomes included FMA-UE.			subacute or chronic stroke (Hedges g = 0.33; 95% CI, 0.16-0.50; I2 = 34.2%). Question 4 Type of device: effects of the end effector device (Hedges g = 0.22; 95% CI, 0.09–0.36; I2 = 35.4%), but not the exoskeleton device, were superior to conventional rehabilitation.	therapy was effective and for which patients The authors conclusions that I have added to the next column are congruent with the data they presented in the paper and their supplementary information.
874	M. Zhao et al (2022). Robot-assisted distal training improves upper limb dexterity and function after stroke: a systematic review and meta-regression. Neurological Sciences. 43: 3. 1641-1657.	SR 22 trials 758 participants Criteria: 18+ Stroke only any chronicity English or Chinese language Ax Primary: distal hand function, dexterity or spasticity Secondary: UL motor function /strength	Intervention: Any robot assisted distal intervention (wrist / hand) either exoskeleton or end-effector Control: Routine care	Primary: Motor function (Fugl-Meyer Assessment of wrist & hand FMA-WH) Hand dexterity (9-hole peg / box and block) ADLs (Modified Barthel) Strength (MRC & Motricity Index) Spasticity – MAS Secondary: FMA-SE(Shoulder &elbow	Evidence ranged from very low to low grade. 50% of trials had high or unclear risk of bias. No trials published protocols and majority undertaken in China. Heterogenous characteristics: mean age 50-73yrs, 15.2 days to 47.9 months post stroke. 19 trials were recurrent stroke.	**+** Acceptable in terms of the review and its candour regarding interpretation of results with caution due to very low-quality evidence. Despite this they did some questionable subgroup analysis and found: Robotic training in addition to routine care to be more effective, as was the combination of VR training and first-time strokes benefitted the most.

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					Targeted various combinations of fingers / hand / wrist / forearm. Training ranged from 2-8/52 and duration 30-120 mins. Variety of outcome measures and timepoints 18 trials had n<35 (only 1 of those with n>35 was reasonable quality – Calabro 2019) 13 trials had cointerventions (majority VR / gaming)	Active-assisted favourable to passive.
874	M. Zhao et al (2022). Robot-assisted distal training improves upper limb dexterity and function after stroke: a systematic review and meta-regression. Neurological Sciences. 43: 3. 1641-1657.	Systematic review and meta regression study reviewing the evidence if robot assisted distal training improves UL dexterity and function after stroke. 11 databased searched from inception until 28 August 2021. 22 trials involving 758 participants were included. Any duration after stroke. Study set in China.	Robot device included hand exoskeleton robot, end-effector robot Amadeus or smart glove. Training involved robot assisted highly repetitive and controlled wrist flexion, extension, abduction, adduction and full finger grasping and releasing. Control groups were therapist assisted training or passive ROM exercises.	Primary outcomes – Fugl Meyer, nine hole peg test, Box and Block test, Ashworth, medical research council scale and motricity scale. Secondary measures – Fugl Meyer, Barthel and stroke impact scale.	Evidence that robot assisted distal training improves upper extremity, motor function, dexterity and spasticity after stroke and these effects are also accompanied by improvements in strength and ADL. Recommend training over 20 sessions, over five times a week for less than four weeks, each session for one hour.	**+** But most trials in China which restricts result generalisability. Results also need to be interpreted with caution because of their v low to low grade of evidence.
875	J.W. Krakauer et al (2021)	Multicentre RCT, 24 subacute stroke patients, FM-UE: 6-40	Neuroananimation therapy combined with an exoskeleton device	Primary: FM-UE Secondary: ARAT Grip strength	No stat sig difference for in any OM at any	**+**

REF ID	Source	Setting, design & subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Comparing a Novel Neuroanimation Experience to Conventional Therapy for High-Dose Intensive Upper-Limb Training in Subacute Stroke: The SMARTS2 Randomized Trial. Neurorehabil Neural Repair. 35: 5. 393–405.		(RT) vs modified conventional OT (CG). Data from a historical cohort (HC) in the Netherlands was used as a comparable standard care group. 2 daily sessions of 60 minutes over 5/7 for 3/52 in addition to usual care for both RT and CG groups.	SIS – hand domain Upper limb kinematics of planar reaching, finger strength and individuation OMs ax at baseline, day 3, 90 and 180	timepoint between RT and CG. Both RT and CG had stat significantly higher ARAT compared to HC group (p=0.011)	Standardisation of intervention and assessment between sites with training. HC data was taken from a different site in a different country. Baseline differences in apraxia and depression between groups. 55 adverse events during study!