Question 28 evidence tables

Question 28: Does arm functional electrical stimulation after stroke improve outcomes?

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

FES = functional electrical stimulation, ARAT = action research arm test, TENS = Trancutaneous Electrical Nerve Stimulation, NMES = Neuromuscular Electrical Stimulation, FES = Functional Electrical Stimulation, tDCS = Transcranial Direct Current Stimulation, TEAS = Transcutaneous Electrical Acupoint Stimulation, ES = electrical stimulation, VAS = Visual Analog Scale, SDQ = Shoulder Disability Questionnaire, MEP = motor evoked potential, TEMPA =Test d'Evaluation des Membres Superieurs des Personnes Agees, FMA = Fugl Myer Assessment Scale, MAL = Motor activity log, WMFT = Wolf Motor function Test, 9HPT = 9-hole peg test, B&BT = Box and block test, MAS = Modified Ashworth scale, UL = upper limb, 6MWT = 6 minute walk test, 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 and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
55	K. N. Arya et al. (2018). Rehabilitation methods for reducing shoulder subluxation in post-stroke hemiparesis: a systematic review[*]. *Topics in Stroke Rehabilitation,* 25:1 68-81	Systematic review; 22 studies (14 RCTs or controlled trials and 8 pre-post-single group studies); Participants: ischemic and hemorrhagic stroke stroke, any age group, both the genders, any phase of recovery, exhibiting any grade of shoulder subluxation. Participants excluded: Traumatic subluxation, shoulder fracture, complex regional pain syndrome, hemiparesis due to head injury. Study designs: randomized controlled trial, pre-post single group design/quasi-experimental studies. Study designs excluded:	Interventions included: rehabilitation techniques such as orthosis, sup-ports/slings, positioning technique, exercises/move- ment therapy, functional/ neuro electrical stimulation, robotic therapy. Interventions excluded: acupuncture, elec-troacupuncture, surgical intervention, intervention to	A range of outcome measures: Shoulder subluxation: acromio-Greater tuberosity distance using radiological such as ultrasonogra-phy and X-ray method. Finger-breadth method to grade shoulder subluxation. Motor recovery: Fugl-Meyer assessment, brunnstorm motor recovery stages	No technique could effectively reduce the subluxation and facilitate the upper limb recovery.	++ Appears well conducted Systematic Review

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		single case study, case series, retrospective studies, cohort studies	prevent shoulder subluxation			
56	A. R. Buick et al. (2016). Tele-Supervised FES-Assisted Exercise for Hemiplegic Upper Limb. *IEEE transactions on neural systems and rehabilitation engineering : a publication of the IEEE Engineering in Medicine and Biology Society,* 24:1 79-87	Study design Before-After observational study. Setting Patients home (community setting), Subjects 11 participants over one year post stroke	Various exericse sessions which were supervised remotely via a webcam. One hour/day five days a week for six weeks.	ARAT, Rejoyce Arm and Hand Function Test, Pinch force, MEP recruitment curves, Psychosocial Impact of Assistive Devices, Measures taken at baseline - pre-treatment, at three-weeks and six weeks.	Results include both with and without FES. Not appropriate to include the with FES so I have presented without FES. ARAT = mean improvement of 5 points (9.5% increase). RAHFT mean improvement of 7 points (10.5% improvement). Pinch force mean improvement of 7.7N. No statistically significant changes in any MEP measures.	This was an observational study with small number of subjects. No comparison group so not appropriate to complete SIGN checklist.
56	A. R. Buick et al. (2016). Tele-Supervised FES-Assisted Exercise for Hemiplegic Upper Limb. *IEEE transactions on neural systems and rehabilitation engineering : a publication of the IEEE Engineering in Medicine and Biology Society,* 24:1 79-87	Setting: Alberta, Canada & Belfast, NI (unclear where patients recruited from). Design: non- randomised feasibility study. Subjects:11 chronic stroke survivors, (ten male, aged 54–86, mean time post-stroke 52 months)	The Rehabilitation Joystick for Arm and Hand Exercise workstation used in homes of chronic stroke survivors to enable tele-coaching of exercises through computer games. Participants performed six weeks of 1 h/day, five days/week Hand opening and grasp were assisted with FES. Participants	ARAT, ReJoyce Arm and Hand Function Test and pinch force assessed pre, mid (3weeks) and post intervention	Improved ARAT scores with one-way repeated measures ANOVA; with FES (p=0.03)and , without FES (p,0.01). The mean ARAT score pre-post increased by 8.8% with FES and 9.5% without FES. Sig increase in RAHFT and pinch force with/ without FES. Mean RAHFT score pre-post increased by 12.1% with FES and 10.5% without FES. Mean pinch force pre-post increased 9.5N with FES and 7.7N without FES. Functional	- Low quality Small feasibillity non-randomised study- not powered for effectiveness. One of the authors developed the rehabilitation joystick used. Numbers of people 'telephone screened' not given. From 30 screened, 11 analysed- not discussed in terms of feasibility.

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			wore a custom-built FES wristlet for extensor and flexor muscles of hand, used to assist with grasping different attachments on the ReJoyce and controlled FES with voluntary toothclicks detected by wireless earpiece		improvements we observed were not accompanied by corresponding changes in the amplitude or latency of TMS responses.	
57	J. S. Knutson et al. (2016). Contralaterally Controlled Functional Electrical Stimulation Improves Hand Dexterity in Chronic Hemiparesis: A Randomized Trial. *Stroke,* 47:10 2596-2602	Single academic clinical centre; Parallel group, assessor-blinded RCT; Stroke patients with chronic (>6 months) moderate to severe upper extremity hemiparesis (n=80)	Cyclical Neuromuscular Electrical Stimulation (cNMES) compared to Contralaterally Controlled Functional Electrical Stimulation (CCFES). For all patients, surface electrodes were positioned over the forearm finger and thumb extensors to produce hand opening. CCFES and cNMES treatments lasted 12 weeks and consisted of (1) 20 sessions of therapist-guided Functional Task Practice (FTP) over 12 weeks, (2) 10	Primary outcome measure: Box & Blocks Test at pre-treatment, week 3, 6, 9, 12 and then 2, 4, 6 months after treatment stopped. Secondary outcome measure: Arm Motor Abilities Test (AMAT) and Upper Extremity Fugl-Meyer scale (UEFM).	29 patients with 6 month follow up in CCFES group (27.5% drop out), 35 patients with 6 month follow up in cNMES group (12.5% drop out). At 6 months post treatment, the CCFES group had greater improvement on the BBT (4.6), than the cNMES group (1.8) with between-group difference of 2.8, P=0.045. No significant between-group difference was found for the uUEFM or AMAT.	++

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			sessions/wk of self-administered repetitive hand opening exercise at home.			
58	S. H. Lee et al. (2018). Virtual Reality Rehabilitation With Functional Electrical Stimulation Improves Upper Extremity Function in Patients With Chronic Stroke: A Pilot Randomized Controlled Study. *Archives of Physical Medicine and Rehabilitation,* 99:8 1447-1453.e1	Pilot RCT, single-blind, n=48 hemiplegic pts, >3mths post stroke, inpatient stroke rehab unit	VR-FES - Intervention Cylical FES - Control 30 min, 5X/week for 4 weeks	Primary: FM UE, WMFT Secondary: Box and blocks, Jebsen-Taylor Hand Function Test, SIS Ax at baseline, 2, 4, 8 weeks	41 participants included in analysis. Larger improvement (statistically significant effect of time x group) in FMA- distal score but did not meet MCID.FMA proximal score improved but not significantly. Marginal significant effect on JTHFT-gross score but not on ine or total score	- Low quality Limitations - no power calculations prior to commencing study to determine sample size. FES was manually triggered in intervention group and cyclic passive participation in control, mechanisms for intervention group - action observation and mental imagery were not present in control. Not clear if VR was what accounted for different outcomes. Mean age of participants was 49 which is younger than the average stroke pt. FMA score change did not meet MCID score
59	C. Marquez-Chin et al. (2017). Functional electrical stimulation therapy for severe hemiplegia: Randomized control trial revisited.	Study design Randomised Controlled Trial Setting Toronto Rehabilitation Institute - seems to have been in-patient setting Subjects 21 patients were recruited within two months of stroke and with a FMA-UE of <15.	Conventional therapy (including electrical therapy for strengthening) versus FES therapy. FES Therapy - initially focussed on reaching	FIM - Self-care subscore and FMA-UE subscores. Measures were taken prior to start of trial and at the end of the treatment phase. No follow-up measures.	FIM Self-care subscores - FES group - BL=8.1 SD=3.3 End=30.9 SD=6.6 Conventional group - BL=8.9 SD=3.5 End=17.9 SD=8.8 Mean difference for FES group=27.8 SD=6.7 Conventional group=9	+ Study is a post-hoc analysis of data from a previous larger study Thrasher et al 2008. Study was adequately blinded and precautions described but

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	Canadian journal of occupational therapy, Revue canadienne d'ergotherapie. 84(2): 87-97	(10 in FES group and 11 in control group) Mean difference of 15 years between the groups ages FES=51 years and Control=65 years.	task and then progressed to grasping tasks. 10 to 50mA at 40Hz. Pulse width controlled 0-300ms. 45 min sessions for up to 5 days a week for 12 to 16 weeks.		SD=6.5 - p=0.001 FMA-UE Subscores - FES group - BL=3.4 SD=4.8 End=30.6 SD=15.5 Conventional group - BL=4.4 SD=4.6 End=9.6 SD=13.7 Mean difference for FES group=27.2 SD=13.5 Conventional group=5.3 SD=11.0 - p=0.001	the assessor did not remain blinded.
59	C. Marquez-Chin et al. (2017). Functional electrical stimulation therapy for severe hemiplegia: Randomized control trial revisited. *Canadian journal of occupational therapy,* Revue canadienne d'ergotherapie. 84(2): 87-97	RCT; Parallel group; n=21 participants with subacute stroke (15 to 57 days post onset) with severe upper limb hemiplegia ;Scores 1-2 in a 7 point arm scale, & & 7 point scale for hand function on Chedoke-McMaster Stages of Moter Recovery and Fugl-Myer Assessment score <=15	Functional Electrical Stimulation and conventional therapy or conventional therapy ;Convential therapy defined as physiotherapy and Occupational Therapy consisting of muscle facilitation exercises, task specific repetiitive functional training , stretching exercises , electrical stimulation for muscle strengthening (not functional training or FES), ADLs including self care involving upper limb and caregiver training . Participants in intervention group received 30.3 hrs of	Fugl-Meyer Assessment Upper Extremity (FMA-UE) & Functional Independence Measure Self Care Subscore	FES therapy combined with conventional therapy showed improvement in FMA-UE scores and FIM Self care subscores	+ Small number of participants . Not clear if participants received physiotherapy and Occupational Therapy .No clarification of proportion of therapies provided in control and intervention groups apart from minutes and days of therapy delivered. Difference in mean age of participants in control group 65 years compared to intervention group 51 years : Mean age of participants is 58.

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			therapy and control group receivded 42.9 sessions.			
60	K. Monte-Silva et al. (2019). Electromyogram-Related Neuromuscular Electrical Stimulation for Restoring Wrist and Hand Movement in Poststroke Hemiplegia: A Systematic Review and Meta-Analysis. *Neurorehabilitation and Neural Repair,* 33:2 96-111	SR & MA; 26 RCT's, 782 patients with UL impairment after stroke	Electromyogram-related Neuromuscular Electrical Stimulation (EMG-NMES) with conventional treatment (CT) or CR only	Impairment, activity, participation measures	Adding EMG-NMES to CT pregrams improves short-term UL impairment in individuals who are more than 3 months post stroke. No evidence in favour of EMG-NMES for activity/participation	++ Lack of positive effects in acute/subacute group. No differences between groups at longer term follow up
60	K. Monte-Silva et al. (2019). Electromyogram-Related Neuromuscular Electrical Stimulation for Restoring Wrist and Hand Movement in Poststroke Hemiplegia: A Systematic Review and Meta-Analysis. *Neurorehabilitation and Neural Repair,* 33:2 96-111	Systematic Review and meta-analyses including Twenty-six studies (782 patients). RCTs on adults with stroke regardless of their initial level of impairment, at any time after stroke. Median PEDRO score of 6 (range 3-8)	The most commonly stimulated muscles were the extensor digitorum communis (EDC), the extensor carpi radialis (ECR), and the extensor carpi ulnaris (ECU). dosage: majority (n = 18), treatment was <20 hours, range 6- 168 hours.Treatment duration 2-20 weeks with frequency varying	The primary analyses focused on Body Structure and Function outcomes, secondary analyses focused on Activity and Participation outcomes	Short term overall medium effect favoring EMG-NMES v control on Body Structure and Function domain in stroke subjects (617 patients, SMD 0.47, P < .001, 95% CI 0.21 to 0.72, I2 = 50%). Patient subgroup analysis, the SMD between the groups favoring EMG-NMES was significant for chronic patients (380 patients, SMD 0.52, P < .001, 95% CI 0.22 to 0.81, I2 = 37%), but not for acute/subacute	++ No concerns noted. As expected, wide range of doses/ treatment parameters.

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			between 1-7/ week and 1-3/day.		patients (237 patients, SMD 0.36, P = .15, 95% CI −0.13 to 0.86, I2 = 68%). No change after sensitivity analysis removing low quality studies. 7 studies showed no effect at follow-up (231 patients, SMD 0.22, P = .20, 95% CI −0.12 to 0.55, I2 = 27%). No differences EMG-NMES v control on Activity at the short-term (562 patients, SMD 0.20, P = .08,95% CI −0.03 to 0.42, I2 = 31%;) or the longer term follow-up time point (303 patients, SMD 0.05, P =.64, 95% CI −0.17 to 0.28, I2 = 0%). Subgroup analyses revealed evidence of an effect on Activity favoring the EMG-NMES groups for chronic (361 patients, SMD 0.29, P = .06, 95% CI −0.02 to 0.60, I2 = 41%), but not for acute/subacute patients (201 patients, SMD 0.00, P = .98, 95% CI −0.28 to 0.28, I2 = 0%;). There was no between-group difference found at the end of treatment based on sensitivity analysis (391 patients, SMD 0.05, P =	

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					.65, 95% CI −0.17 to 0.27, I2 = 12%).	
61	G. F. Nakipoglu Yuzer et al. (2017). A Randomized Controlled Study: Effectiveness of Functional Electrical Stimulation on Wrist and Finger Flexor Spasticity in Hemiplegia. *Journal of Stroke and Cerebrovascular Diseases,* 26:7 1467-1471	Single hospital centre; 'double-blind' parallel group RCT (although patients could not be blinded, not clear if assessors were blinded); Stroke patients >3 months post-stroke, Modified Ashworth at least 2; 30 patients, 15 in each group, randomised by coin flip (not clear who did this).	Study group received passive cyclical electrical stimulation to wrist and finger extensors of affected side; 30 mins/day, 5 days/week, 4 weeks = 20 sessions PLUS conventional passive stretching and resting splint. Control group just received conentional passive stretching and resting splint.	Outcomes listed as Passive and Active Range of Movement (PROM, AROM), modified Ashworth Sale (MAS), Rivermead Motor Assessment (RMA), Brunnstrom staging (BS), Barthel Index (BI), Upper Extremity Functional Test (UEFT). Primary outcome not defined.	AROM, PROM, BI all improve in study group but not control group. There was no difference in the change in other outcome scores between the tretment and study groups. Not sure the correct abnalysis has been done (either diffeerence in change scores or difference in post treatment correcting for baseline scores). 'Qulalitative' description of more patients moving from Modified Ashworth Scale 3 score of to 2 in study group (80% to 46.7%) compared to control group (46.7% to 40%) but groups not matched for baseline MAS.	**0** Relatively low quality - randomisation may not have been blinded; groups not balanced for spasticity; no primary outcome measure and changes in some but not other outcome measure.
62	S. Page et al. (2019). A Randomized Controlled Trial Comparing EMG-Triggered, Cyclic, and Sensory Electrical Stimulation. *Archives of Physical Medicine and Rehabilitation,* 100:10 e37	Setting - Multicentre community settings Design Single blind multiarm parallel group study. Subjects 109 participants completed treatments and 83 completed outcome assessments.	Cyclic Electrical stimulation, EMG triggered electrical stimulation or sensory stimulation provided for 80 minutes/day over an 8 week period.	FMA and modified Arm Motor Ability Test (mAMAT)	Significant increases in FMA mAMAT for all groups but no significant difference between groups.	- Unable to analyse internal validity due to Poster Abstract - not enough information provided regarding blinding, participant demographics and cause of substantial drop-out from study.

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62	S. Page et al. (2019). A Randomized Controlled Trial Comparing EMG-Triggered, Cyclic, and Sensory Electrical Stimulation. *Archives of Physical Medicine and Rehabilitation,* 100:10 e37	Mulit-centre, single-blind, multi-arm, parallel-group study of non-hospitalised subacute stroke patients (within 6 mths of stroke), n=122.	Cyclic NMES, EMG-triggered NMES or sensory stimulation (control). Administered twice daily in 40 min sessions for 8 weeks (mon - fri)	Outcome assessment completed at baseline, mid treatment, end of treatment, 1, 3 and 6 months after treatment. Primary: FMA UE Secondary: Arm motor ability test (AMAT)	There were sigificant increases in FMA ($p < .001$), FMA wrist and hand ($p < .001$) and mAMAT ($p < .001$) in all 3 groups. There was no significant difference in the improvement between groups on either primary or secondary outcomes.	- Low quality - Slow recruitment and therefore underpowered. Unclear whether percentage differences in stage of recovery would impact result (26.2% vs 30% vs 44.7%). Control group also had stimulation although below threshold to illicit motor response.
63	T. Sentandreu-Mano et al. (2021). A randomised clinical trial comparing 35 Hz versus 50 Hz frequency stimulation effects on hand motor recovery in older adults after stroke. *Scientific reports,* 11:1 9131	RCT; parallel group, single-blind; n=69 older adults with spastic hemiparesis of hand after stroke	NMES with 50 Hertz or 35 hertz 3 sessions per week for 8 weeks and conventional rehabilitation (CR), control group received CR only	Range of motion, hand strength, muscle tone, muscle electrical activity, function	NMES groups showed more significant changes in range of motion, grip and pinch strength, tone and muscle electrical activity in wrist extensors compared to the control group. Only the 35Hz NMES group showed significant effect on function at all three time points	- Not reported if assessors were blinded to group allocation
63	T. Sentandreu-Mano et al. (2021). A randomised clinical trial comparing 35 Hz versus 50 Hz frequency stimulation effects on hand motor recovery in older adults after stroke. *Scientific reports,* 11:1 9131	Setting: Spain but limited details given. Design: 3 arm RCT (control and 2 doses of NMES). Subjects: 69 stroke survivors over 5 years, criteria >60yrs old (?why), 5/6mths post stroke	control v 35Hz v 50Hz NMES, 8-week intervention period,3 days / week (a total of 24 sessions). The two experimental groups received the conventional treatment (the same as the control group),	motor impairment (range of motion, grip and pinch strength, muscle tone and muscle electrical activity) and upper limb function (manual dexterity and functional independence	NMES groups showed significant changes ($p < 0.05$) with different effect sizes in ROM, grip and pinch strength, the Modified Ashworth Scale, and the muscle electrical activity in the extensors of the wrist. The 35 Hz NMES intervention showed a significant effect on Barthel	- Low quality Unclear consort diagram in terms of reasons for exclusions, recuited 69 people over 5 years.assessors not blinded. Some dubious statistics (chi-square for qualitative), lots of measures and timepoints- no a priori

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			plus NMES. NMES time was 20 min for first 2 sessions and 30 min for subsequent sessions.		Index. No significant differences between the groups in the Box and Block Test	primary measure.Used ANCOVA within group, no between group analysis
64	Y. Tang et al. (2021). Optimal method of electrical stimulation for the treatment of upper limb dysfunction after stroke: A systematic review and bayesian network meta-analysis of randomized controlled trials. *Neuropsychiatric Disease and Treatment,* 17: 2937-2954	Network Meta-Analysis (pairwise meta-analysis and Bayesian network meta-analysis with assessment of risk of bias, publication bias and sensitivity of the RCTs) to identify the most effective types of electrical stimulation Subjects - stroke survivors with upper limb limitations	Comparing Transcutaneous Electrical Nerve Stimulation (TENS), Neuromuscular Electrical Stimulation (NMES), Functional Electrical Stimulation (FES), Transcranial Direct Current Stimulation (tDCS) and Transcutaneous Electrical Acupoint Stimulation (TEAS).	The primary outcome was weakness (AKA UL impairment or motor control) measured by Fugl-Meyer Assessment Upper Extremity (FMA-UE), and the secondary measures were activites of daily living (Modified Barthel Index) and spasticity (Modified Ashworth Scale).	34 studies involving 2383 patients were selelcted. FES was superior to other electrical stimulation methods for upper limb impairment/motor control/weakness and actvites of daily living. Spasticity - TENS reduced upper limb spasticity and was more effective than other electrical stimulation methods	++
64	Y. Tang et al. (2021). Optimal method of electrical stimulation for the treatment of upper limb dysfunction after stroke: A systematic review and bayesian network meta-analysis of randomized controlled trials. *Neuropsychiatric Disease and*	Systematic Review and Network meta analysis: Total of 34 RCTS n=2383 with isachemic or hamorrhagic stroke .Need to access appendix to determine patient characteristics .	Trancutaneous Electrical Nerve Stimulation (TENS),Neuromuscular Electrical Stimulation (NMES),Functional Electrical Stimulation (FES),Transcranial Direct Current Stimulation(tDCS) & Transcutaneous Electrical Acupoint Stimulation (TEAS)		Functional Electrical Stimulation (FES) was superior to other forms of electrical stimulation in improving FMA-UE and MBI .	+ Limitations : all stroke patients , no clarification if acute , subacute , chronic. The duration and dose of electrical stimulation varied across RCTs .

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	Treatment, 17: 2937-2954		combined with Rehabilitation Treatment (RT)			
65	S. Tashiro et al. (2019). Neuromuscular electrical stimulation-enhanced rehabilitation is associated with not only motor but also somatosensory cortical plasticity in chronic stroke patients: an interventional study. *Therapeutic Advances in Chronic Disease,* 10: no pagination	Setting - Out-patient stroke rehabilitation clinic Design - pre-specified analysis of participants in an ongoing large interventional (presumably cohort) study Subjects - 23 with chronic stroke and severe upper limb weakness	3 weeks of inpatient HANDS therapy (Hybrid assistive neuromuscular dynamic stimulation) where daily treatment consisted of 8 hrs of NeuroMuscular Elelctrical Stimulation (NMES) combined with wrist splinting, 90 min OT and practice of bimanual activities of daily living.	Somatosensory evoked potentials and sensory assessments, including the Semmes–Weinstein monofilament test (sensory threshold/light touch) and thumb localizing test (propriocpetion) tested before and after intervention	No significant change in the percpetion of light touch (Monofilament test) or sensory evoked potential of the median nerve, but there was improvmetns in the thumb location test (propriocpetion) or sensry evoked potentials of the ulnar nerve. However the lack of randomisation; control group and the mixed intervention means that any improvments cannot be ascribed to the intervention, or any aspect of the intervention	+
65	S. Tashiro et al. (2019). Neuromuscular electrical stimulation-enhanced rehabilitation is associated with not only motor but also somatosensory cortical plasticity in chronic stroke patients: an interventional study. *Therapeutic Advances*	Participants were selected from an ongoing large interventional study. Inpatient setting, at least 6 months post stroke, severe UL weakness, n=23	3 weeks of inpatient hybrid assistive neuromuscular dynamic stimulation (HANDS) utilizing closed-loop electromuography-controlled neuromuscual electrical stimulation - 8hrs of NMES combined with wrist splinting. 90 min of OT	SEP parameters, Semmes Weinstein monofilament and thumb localizing test (TLT). Also FMA - UL and MAS, SIAS and MAL-14 were conducted - 1 day before and 1 day after the HANDS intervention.	Number of cortical peaks significantly increased in the median nerve but not in the tibial nerve (pseudo control). No significant recovery of tactile sensation was observed on the monofilaments. Significant improvement was observed on the TLT (p= 0.018) Significant recovery of motor function in all 4 sub scores of the FMA - UL (distal scores(B:	- Low quality - No control group, no blinding in baseline or outcome assessment. Cannot exclude possibility of selection bias and small number of participants who are not representative of the stroke population as a whole. Not clear how much of each component was delivered

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	in Chronic Disease, 10: no pagination		and practice of bimanual activites of daily living 5 days per week. Sessions included passive stretching + active reeducation of the paretic UE (ie shaping tasks). Rehab nurses instructed and encouraged participants to use their paretic limb during tasks associated with real-life ALD's on the ward. Self assessment monitoring sheets were used and Motor activity log (MAL 14). Participants were also given homework tasks and received onventional physiotherapy.		hand joint and C: hand and finger) and proximal scores (A: shoulder, elblow and forearm function and D: coorindation and speed of gross proximal movement) No significant changes in spasticity MAL-14 - results indicated that practical daily use of the paretic UL significantly improved following the intervention ($p< 0.0001$) SIAS - significant functional recovery for finger function only.	
66	C. Turkkan et al. (2017). Ultrasonographic assessment of neuromuscular electrical stimulation efficacy on glenohumeral	Setting- Design - prospective, RCT Subjects - 24 strokes with Glenohumeral subluxation - 12 in active treatment group .	NeuroMuscular Electrical Stimulation (NMES) to supraspinatus, upper trapezius, and posterior deltoid muscles combined (60 min/day, 5 days/ week	Brunnstrom Motor Recovery Stage (weakness/impairment); Visual Analog Scale [VAS] for Pain; Shoulder Disability Questionnaire [SDQ]) (Arm function);	The analysis compared data before and after treatment each group sperately. There only comparison between groups was of the "% change in scores before and after treatment", which is an inappropriate use of data.	**+** Low quality trial. No sample size calculation(clearly underpowered); no metion of concealed allocation; blinded assessment; drop out rates. Strange analysis

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	subluxation in patients with hemiplegia: A randomized-controlled study. *Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi,* 63(4): 287-292		for 4 weeks, total of 20 sessions). Plus conventional physiotherapy (shoulder strap, range of motion, stretching, and strengthening exercises). Control = convnetional therapy alone	Ultrasonographic (acromion-greater tuberosity distance)-subluxation evaluated before and after treatment in both groups.	However the authors claim that the subluxation (distance between acromion nad greater tuberosity) showed a signficant difference (p=0.03) in favour of NMES. No dfferences were reported in the other outcomes. in the within-group comparison, the intervention group showed significant improvement in subluxation (p<0.05), pain (p<0.05) and function (p<0.02) after treatment. The control group showed improvements in pain 9p<0.01) only.	
66	C. Turkkan et al. (2017). Ultrasonographic assessment of neuromuscular electrical stimulation efficacy on glenohumeral subluxation in patients with hemiplegia: A randomized-controlled study. *Turkiye Fiziksel Tip ve Rehabilitasyon Dergisi,* 63(4): 287-292	Single centre reahbilitation hospital; Parallel group RCT; 24 stroke patients admitted to rehabilitation centre with diagnosis of glenohumeral subluxation	Patients randomised to NMES + conventional therapy or conventional therapy alone. NMES was applied to upraspinatus, upper trapezius, and posterior deltoid muscles of the hemiplegic side for 60 min/session in a day, and five days a week for four weeks (a total of 20 sessions). Conventional therapy - all patients used a	Brunnstrom Motor Recovery Stage (BMRS), Shoulder Disability Questionnaire (SDQ), Visual Analog Scale for Pain (VAS-pain). Ultrasound measures were Acromion-greater tuberosity (A-GT) distance and thicknesses of supraspinatus, upper trapezius, and posterior deltoid muscles were measured. The Mann-Whitney U and Fisher's exact tests were used to compare demographic,	It is unclear hwere a direct statistical comparison has been made between the study and control groups, although the paper states 'the change of Acromion-greater tuberosity (A-GT) distance was more improved in the NMES group than the control group' (p=0.03). The changes of other measurements were not significant statistically (for all p>0.05). The abstract concludes that subluxation (measured by A-GT).	**0** Relatively low quality - not clear that correct statistical comparison has been made. No primary outcome listed.

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			shoulder strap and received similar conventional physiotherapy for GHS (range of motion, stretching, and strengthening exercises).	clinical, and USG variables between the two groups, but no primary outcomes/analysis listed.		
67	J. D. Yang et al. (2019). Effectiveness of electrical stimulation therapy in improving arm function after stroke: a systematic review and a meta-analysis of randomised controlled trials. *Clin Rehabil,* 33:8 1286-1297	All settings. SR with meta-analysis. RCTs reporting the effects of electrical stimulation on arm function after stroke were selected from searches of PubMed, Cochrane Library, Embase, and Scopus. Trial quality was assessed using the Cochrane Risk of Bias Tool. Pooled data were analyzed using a random effect model. Publication bias was evaluated graphically by using funnel plots. Statistical heterogeneity, calculated using the I2 test, was considered high when it exceeded 75%. In the case of high heterogeneity a sensitivity analysis was conducted to confirm its effect after adjustment of the included data.	Sensory, cyclic, or EMG-triggered elelctrical stimulation (AKA FES) + usual care (rehabiltaiton program or functional task practice) compared with placebo	Upper limb impairments and activity. Primary outcome was UL impairment measured by the Fugl-Meyer Assesssment immediately before and after treatment and at follow-up. Actvity/Disabilites assessed were Action Research Arm Test, Jebsen–Taylor Hand Function Test, Wolf Motor Function Test, Box and Block Test, and Motor Activity LogSecnd outcome was the a comparison of the differet types of stimulation.	48 RCTs with 1712 patients were included. The stimulation protocols were highly varied (frequencies ranged from 14 - 100 Hz. Treatment duration/ session ranged from 20 minutes to 12 hours.Treatment frequency ranged from 3x/wk to 3x/day. Total treatment duration ranged from 1 day to 5 months. UL FMA had better outcomes in the ES group than placebo immediately after treatment (23 RCTs (n = 794): SMD = 0.67, 95%CI = 0.51–0.84) and at follow-up (12 RCTs (n = 391): SMD = 0.66, 95% CI = 0.35–0.97). For activity: The ARAT showed better outcome in the ES group than placebo immediately after treatment (10 RCTs (n = 411): SMD = 0.70, 95% CI = 0.39–1.02) and	++

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					at follow-up (8 RCTs (n = 289): SMD = 0.93, 95% CI = 0.34–1.52). Other activity assessments (Wolf Motor Function Test, Box and Block Test, and Motor Activity Log) also revealed superior outcomes in the ES group than placebo group. Comparisons between three types of ES (sensory, cyclic, and electromyography-triggered electrical stimulation) groups revealed no significant differences in the body function and activity. Assessment of strength, range of movment and spasticity was manly inconclusive because of small mnumbers.	
67	J. D. Yang et al. (2019). Effectiveness of electrical stimulation therapy in improving arm function after stroke: a systematic review and a meta-analysis of randomised controlled trials. *Clin Rehabil,* 33:8 1286-1297	SR with meta-analysis including 48 RCTs with 1712 patients reporting the effects of electrical stimulation on arm function after stroke. Trial quality was assessed using the Cochrane Risk of Bias Tool.	Sensory, cyclic, or EMG-triggered elelctrical stimulation + usual care (rehab program or functional task practice) compared with placebo	UE FMA scores, in the electrical stimulation and placebo groups immediately after treatment and follow-up. UE FMA scores in comparison between the 3 types of electrical stimulation (EMG-triggered, cyclic, or sensory electrical stimulation) immediately	Varied stimulation protocols (frequencies ranged from 14 - 100 Hz. Treatment duration/ session ranged from 20 minutes to 12 hours.Treatment frequency ranged from 3x/wk to 3x/day. Total treatment duration ranged from 1 day to 5 months. UE FMA indicated more favorable outcomes in the electrical	++

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
				after treatment & follow-up. Body function assessments, including muscle strength, range of motion, and spasticity. Actvity/Disabilites assessed were Action Research Arm Test, Jebsen–Taylor Hand Function Test, Wolf Motor Function Test, Box and Block Test, and Motor Activity Log	stimulation group than in the placebo group immediately after treatment (23 RCTs (n = 794): standard mean difference (SMD) = 0.67, 95% confidence interval (CI) = 0.51–0.84) and at follow-up (12 RCTs (n = 391): SMD = 0.66, 95% CI = 0.35–0.97). The activity assessment, Action Research Arm Test, revealed superior outcomes in the electrical stimulation group than those in the placebo group immediately after treatment (10 RCTs (n = 411): SMD = 0.70, 95% CI = 0.39–1.02) and at follow-up (8 RCTs (n = 289): SMD = 0.93, 95% CI = 0.34–1.52). Other activity assessments found superior outcomes in the electrical stimulation group than those in the placebo group. Comparisons between three types of electrical stimulation (sensory, cyclic, and electromyography-triggered electrical stimulation) groups revealed no significant differences in the body function and activity.	

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
67	J. D. Yang et al. (2019). Effectiveness of electrical stimulation therapy in improving arm function after stroke: a systematic review and a meta-analysis of randomised controlled trials. *Clin Rehabil,* 33:8 1286-1297	All settings. SR with meta-analysis. RCTs reporting the effects of electrical stimulation on arm function after stroke were selected from searches of PubMed, Cochrane Library, Embase, and Scopus. Trial quality was assessed using the Cochrane Risk of Bias Tool. Pooled data were analyzed using a random effect model. Publication bias was evaluated graphically by using funnel plots. Statistical heterogeneity, calculated using the I2 test, was considered high when it exceeded 75%. In the case of high heterogeneity a sensitivity analysis was conducted to confirm its effect after adjustment of the included data.	Sensory, cyclic, or EMG-triggered electrical stimulation (AKA FES) + usual care (rehabilitation program or functional task practice) compared with placebo	Upper limb impairments and activity. Primary outcome was UL impairment measured by the Fugl-Meyer Assessment immediately before and after treatment and at follow-up. Activity/Disabilities assessed were Action Research Arm Test, Jebsen–Taylor Hand Function Test, Wolf Motor Function Test, Box and Block Test, and Motor Activity LogSecnd outcome was the a comparison of the different types of stimulation.	48 RCTs with 1712 patients were included. The stimulation protocols were highly varied (frequencies ranged from 14 - 100 Hz. Treatment duration/ session ranged from 20 minutes to 12 hours. Treatment frequency ranged from 3x/wk to 3x/day. Total treatment duration ranged from 1 day to 5 months. UL FMA had better outcomes in the ES group than placebo immediately after treatment (23 RCTs (n = 794): SMD = 0.67, 95%CI = 0.51–0.84) and at follow-up (12 RCTs (n = 391): SMD = 0.66, 95% CI = 0.35–0.97). For activity: The ARAT showed better outcome in the ES group than placebo immediately after treatment (10 RCTs (n = 411): SMD = 0.70, 95% CI = 0.39–1.02) and at follow-up (8 RCTs (n = 289): SMD = 0.93, 95% CI = 0.34–1.52). Other activity assessments (Wolf Motor Function Test, Box and Block Test, and Motor Activity Log) also revealed superior outcomes in the ES group than placebo group. Comparisons	++

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					between three types of ES (sensory, cyclic, and electromyography-triggered electrical stimulation) groups revealed no significant differences in the body function and activity. Assessment of strength, range of movement and spasticity was manly inconclusive because of small numbers.	
67	J. D. Yang et al. (2019). Effectiveness of electrical stimulation therapy in improving arm function after stroke: a systematic review and a meta-analysis of randomised controlled trials. *Clin Rehabil,* 33:8 1286-1297	SR with meta-analysis including 48 RCTs with 1712 patients reporting the effects of electrical stimulation on arm function after stroke. Trial quality was assessed using the Cochrane Risk of Bias Tool.			Sensory, cyclic, or EMG-triggered electrical stimulation + usual care (rehab program or functional task practice) compared with placebo	UE FMA scores, in the electrical stimulation and placebo groups immediately after treatment and follow-up. UE FMA scores in comparison between the 3 types of electrical stimulation (EMG-triggered, cyclic, or sensory electrical stimulation) immediately after treatment & follow-up. Body function assessments, including muscle strength, range of motion, and spasticity. Activity/ Disabilities assessed were Action Research Arm Test, Jebsen–Taylor Hand Function Test, Wolf Motor Function Test, Box and Block Test, and Motor Activity Log
693	M. S. Loh et al. (2022). Upper Extremity Contralaterally	SR and MA to summarize the effect size	Participants: Stroke of any phase, sex, age, or ability level	Very little information about the dose or parameters of stimulation	Upper limb impairment and activity: Upper Extremity Fugl-Meyer assessment	Although the results suggest CCFES may have a greater impact on UL impairment and

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Controlled Functional Electrical Stimulation Versus Neuromuscular Electrical Stimulation in Post-Stroke Individuals: A Meta-Analysis of Randomized Controlled Trials. Neurorehabilitation and Neural Repair 36:7 472-482	PubMed, Cochrane Library, EMBASE, Scopus, and Google Scholar searched for RCTs. Risk of bias assessment applied.	Contralaterally Controlled Functional Electrical Stimulation (CCFES) on upper limb impairment and activity compared to neuro-muscular electrical stimulation (NMES) or placebo.		(UEFMA) was included in all studies, the Box and Blocks test (BBT) and active range of motion (AROM) were included in 3 and 4 studies, respectively. The modified Barthel Index (mBI) and Arm Motor Abilities Test (AMAT) 6 RCTs selected (n= 267 (137 received CCFES), range 17-72). 1 = acute stage; 3 = sub-acute; 1 sub-acute and chronic; 1 = chronic. No info about participants' level of impairment/stroke severity. 4 studies were at low risk of bias; one had concerns, and 1 was high risk. CCFES showed greater improvement NMES in UEFMA (SMD= 0.42, 95%CI= 0.07–0.76), BBT (SMD= 0.48, 95%CI = 0.10–0.86), AROM (SMD= 0.54, 95%CI = 0.23–0.86) and mBI (SMD= 0.54, 95%CI= 0.12–0.97). No difference for the AMAT (SMD= 0.34, 95%CI= –0.03 to 0.72).	activity than NMES, the number of trials and participants, particularly in outcomes with <6 trials are tiny. Thus any application should be treated with great caution, however it adds to other studies indicating than FES may be more effective than NMES so we could tweak the wording to that bit and add to the references.
692	M. G. H. Kristensen et al. (2022). Neuromuscular Electrical Stimulation Improves Activities of	SR and MA of RCTs of effectiveness of neuromuscular electrical stimulation (NMES). No info about the controls except "the only difference between the	NMES to the upper or lower limbs using surface electrodes that produced a visible muscle contraction.	Activities of daily living (ADL) – primary and impairments/ activity (referred to as 'functional motor abilities').	20 selected; 13 ADL and 10 impairment/ activities in sub-acute and chronic stroke; n= 428 and 659 respectively. Mean PEDro score = 5.8	Evidence level is good, but the number of trials and participants are small. The sub-group analyses are tiny. All should be treated with caution.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Daily Living Post Stroke: A Systematic Review and Meta-analysis. *Archives of Rehabilitation Research and Clinical Translation* 4:1 100167	control and intervention groups was administration of NMES" I. and (2) to investigate the influence of paresis and the timing of treatment. Data Sources: PubMed, MEDLINE, Embase, Physiotherapy Evidence Database (PEDro) and Cochrane Library up to May 2020. Two independent reviewers. Quality assessed using the PEDro scale and Cochrane Risk of Bias Tool.	EMG-triggered ES or FES excluded. 13 trials stimulated the UL, mainly shoulder abductors and wrist extensors +/- other muscle groups eg wrist flexors, elbow extensors, +/or finger extensors +/or flexors. 7 trials stimulated the LL, mostly ankle dorsal flexors +/- hip and knee flexors and extensors, toe extensors, and ankle evertors. Intervention duration = 3 weeks to 3 months, most frequently stimulation sessions of 10-60 mins, 1-4 times daily, and 3-7 weekly for 3-4 weeks. Typical stimulation protocol = cyclic Stimulation, at frequency of 30 Hz (range 1.7-100Hz) with fixed pulse width (200-300 ms, range, 100-450ms).	ADL= Barthel Index Impairments'/activity = Action Research Activity Test; Box and block test and Motor Assessment Scale	(range, 4-8) with 13 trials rated as good. NMES had a positive effect on ADL (SMD= 0.41; 95%CI 0.14-0.67; P=.003) in the subacute stage (SMD= 0.44 95%CI 0.09-0.78; P=.01) but not chronic stroke (SMD= 0.35 95%CI -0.14 to 0.84; P=.16). Severity of weakness was not a factor; both moderate (SMD=0.21 95%CI -0.16 to 0.58; P=.26; n=3) and severe (SMD= 0.36 95%CI -0.55 to 1.26; P=.44; n=3) subgroups showed non-significant effects.	However, indicates that NMES can improve ADL in sub-acute stroke. Non-significant differences for chronic stroke and impairment/activity Severity of weakness was not a factor.

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			Amplitude generally individually adjusted to get a visible muscle contraction or joint movement			