Question 32 evidence tables

Question 32: Does mental practice/guided imagery improve arm function after a stroke?

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

MP = mental practice, MI = motor imagery, AO = action observation, MSK = musculoskeletal, LF-rTMS = low frequency transcranial magnetic stimulation, MMP = multimodal mental practice, OT = occupational therapy, ES = electrical stimulation, BCI = brain-computer interface, 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, 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
409	A. R. Alashram et al. (2020). Mental Practice Combined With Physical Practice to Enhance Upper Extremity Functional Ability Poststroke: A Systematic Review. *Journal of Stroke Medicine,* 3:2 51-61	Systematic review. Italy. Two reviewers Randomized clinical trials investigating the effect of combined PP and MP. Any disagreement reviewers resolved by discussion. Electronic search of PubMed produced a total of 1256 articles. removed duplicates, 731 articles were reviewed. 667 excluded (did not match the inclusion criteria).55 articles were eliminated: not RCT and data outcome measurements were not reported. In this review, a total of 9 RCT. Subjects: 230 participants. All stroke acute, subacute, chronic mixed.	PP & MP. 3 studies=10 wks in length 5 =6 wks 1= 5 wks performed: 3 =3 x a WK 3=2 x a WK 3= 2 to 3 x a WK Session Duration: 6= MP 20-45 mins 1 =MP 60mins 2 =MP 10 mins Performed practice: 1=MP=3 x daily 20min 1= MP 3 x daily 10 min 1 =MP 2x daily 60 min Practised Physically (includes mCIMT, task-specific training and traditional rehab) 4 studies =30 mins	7 of 9 studies used ARAT, Fugl-Meyer scale (n = 6),the arm functional test functional ability scale (n = 1), and the Motor Activity Log (n = 1),Frenchay activities index (n = 1), Frenchay arm test (n = 1).	Combining of MP and PP would be more effective in improving the hemiparetic upper-extremity functions post stroke than PP alone. Proposed 30to 60 min of PP followed by 30 min of MP 2 to 3 times per week for 6 to 10 weeks	**+** Small sample sizes 10 to 42. Only 2 studies reported concealed allocation. Could lead to selection bias. The selected studies did not blind participants and therapists to the MP intervention. Difficult to determine who most likely benefitted from the intervention. The optimal time to start the intervention was not identified. The quality of further studies should improve by using greater sample sizes, ensuring the blinding of the assessors .

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		This systematic review is reported according to the PRISMA Guidelines.	4=60mins 1 =10 mins MP, 8 of 9 studies used audiotaped remaining used videotaped instructions alone			
412	R. E. Barclay et al. (2020). Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. *Cochrane Database of Systematic Reviews,* 2020:5 CD005950	Setting: Various Country: Various x9 Designs: Parallel group RCT & cross over trials (First period only) Subjects: Adults post stroke 25 studies: n=676 Subgroup analysis for: 1.Chronicity of </> 6/12 post stroke 2. Influence of dose: </> 360 minutes of MP 19 additional studies to the 6 studies from original 2011 Cochrane	MP in addition to treatment (21 studies) MP v's conventional treatment (4 studies) Varied content of MP in varied doses (50 - 375 mins a week over 2 – 16 weeks) Combined with a variety of other interventions in different ways e.g. undertaken alongside / following / alternate days	Primary: Measures of activity e.g. Box & Block, Action Research Arm, Wolf Motor Function & Motor Activity Log Secondary: Function / impairment e.g. Fugl-Meyer Sensorimotor Chedoke-McMaster impairment inventory ADL's e.g. Barthel Index Functional Independence Measure Stroke Impact Scale	MP in addition to treatment v's treatment alone: MP in combination more effective in improving: UL activity (Standard Mean Diff 0.66, 95%CI 0.39 to 0.94, 15 studies / n=397) (mod GRADE) UL impairment SMD 0.59, 95% CI 0.30 to 0.87, 15 studies / n=397 (mod GRADE) ADL's SMD 0.08, 95%CI -0.24 to 0.39, 4 studies / n=157 (low GRADE) MP v's conventional treatment: UL impairment (only available outcome) SMD 0.34, 95%CI -0.33 to 1.00, 3 studies / n=50 (low GRADE) Subgroup analysis: no significant differences	**+** Acceptable. "Moderate certainty evidence that MP when combined with other treatment is beneficial in improving UL activity and impairment after stroke".

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
412	R. E. Barclay et al. (2020). Mental practice for treating upper extremity deficits in individuals with hemiparesis after stroke. *Cochrane Database of Systematic Reviews,* 2020:5 CD005950	Systematic review & Meta-analysis (Cochrane). Evaluating the effect of mental practice on impairment and ADL. This is an updated review of one completed in 2011 (6 studies). This review included 25 studies (676 participants) incl all 6 from original review. The quant synthesis was able to analyses22 of the studies	Mental Practice: 21/25 paired MP with a conventional treatment 4/25 studies administered MP alone	Primary outcomes focused on activity and activity limitations of the upper extremity e.g: BBT, ARAT, WMFT, MAL Secondary outcomes FMA (incl sens), Chedoke, Barthel, FIM	"Moderate-quality evidence shows that mental practice (MP) in combination with other treatment appears to be beneficial in improving upper extremity activity and upper extremity impairment after stroke as compared with other treatment without MP" The evidence for ADL improvement is limited.	**++** High quality. Methodologically this is a well conducted review. Major limitations are small sample sizes of the included studies and their heterogeneity.
414	T. C. L. S. Gaughan & S. G. Boe (2021). Investigating the dose-response relationship between motor imagery and motor recovery of upper-limb impairment and function in chronic stroke: A scoping review. *Journal of neuropsychology,* :	It is a scoping review to determine the relationship between MI dose and recovery. It included all types of study (not just RCTs) and aimed to investigate multiple factors in 'dose' : frequency, intensity, time and type. The authors were seeking to identify gaps in the MI literature. 21 studies were included: 447 participants, 228 underwent MI intervention, average number of participants per study 18 (control) 16 (treatment). Of the 21 studies 19 were RCTs, 2 were case studies.	Four different types of MI were found in the 21 studies, most common form of instruction was by audio recording, 6 different task types ranging from one to five tasks, daily activities most common, recreational sports and mirror box imagery present in two studies. Wide variation in dose frequency and amount.	10 different outcomes used, FMA most common effect sizes calculated (Hedge's g).	Great variation in dose regimens with no clear pattern of the effect of dose on outcome.	**+** The findings do not change the information for the clinical guidelines.
414	T. C. L. S. Gaughan & S. G. Boe (2021). Investigating the dose-response relationship	Scoping review of the literature. The review searched Medline, CINAHL and Embase for studies written in English that reported	MI (kinaesthetic or visual), either in isolation or combined with physical practice	A measure of function or impairment to report pre and post-intervention changes. Hedges g was	21 articles were included and data extracted, n=447; 2 case studies, 19 RCTs in people who were an average of 6.8	**+** Not an SR but no scoping review checklist.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	between motor imagery and motor recovery of upper-limb impairment and function in chronic stroke: A scoping review. *Journal of neuropsychology,* :	pre and post change scores after an motor imagery intervention. Population: studies including human adult participants (>18 years old) in the chronic stage of stroke recovery(>3 months). Intervention: MI (kinaesthetic or visual), either in isolation or combined with physical practice or another adjunct therapy; Procedure: MI procedure clearly defined (i.e., session length and total time in therapy); Outcome: utilizes a measure of function or impairment to report pre and post-intervention changes.	or another adjunct therapy.	used to compare effect sizes.	months after stroke (range 3 months to 6 years). 18 studies reported that MI plus physical practice was effective, but 3 studies found no difference between MI& physical practice vs physical practice alone. The average treatment dose was 31 minutes and MI was delivered between 2/week upto 5/week – there was no trend for frequency and effect size nor dose and effect size. One included study found a lower dose per day had a larger benefit that a higher dose per day.	
415	Z. F. Guerra et al. (2017). Motor Imagery Training After Stroke: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Journal of neurologic physical therapy : JNPT,* 41:4 205-214	A systematic review and metal analysis of randomized controlled trials investigating the efficacy of MI for recovery after stroke for both motor and sensory recovery. 32 articles were included. No restrictions on type of stroke or time since event. Study set in Brazil.	Motor imagery entailed the cognitive tasks of imagining the performance of a given movement or specific task. Intervention protocol with MI had to entail individuals performing mental imagery of specific movements or tasks, without restriction on MI strategy such as visual or kinesthetic imagery or number of repetitions.	Addressed effects of MI on performance of ADL and on motor function. 5 studies assessed performance of ADL, 12 assessed effects on motor recovery of lower limb and/or gait and 20 studies assessed performance and motor recovery of upper limb.	High heterogeneity in methodological quality of the studies and conflicting results. Wide range of MI protocols, participants at different times after stroke and used a large variety of assessment methods.	**+** Acceptable study. When only high quality studies include no significant difference between the MI an control groups was found.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			Participants performed MI in association with conventional or traditional physical and/or occupational therapy.+			
415	Z. F. Guerra et al. (2017). Motor Imagery Training After Stroke: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Journal of neurologic physical therapy : JNPT,* 41:4 205-214	Systematic Review with Meta-Analysis. Protocol registered on PROSPERO. All included studies were randomised trials. Participants: clinically diagnosed with stroke at any time after onset.	Clinical trials of individuals performing mental imagery of movements or tasks, no restriction of MI strategy or repetitions.	Primary outcomes were effects of MI on ADL and motor function of balance, gait and upper limb. Studies were sub-divided for analysis into these four groups, following retrieval of full texts, due to diversity of studies retrieved. Meta-analysis carried out to compare intervention and control: three analyses- 1)all studies 2)according to outcome scale used (Timed Up & Go, TUG; Action Research Arm test, ARAT; Fugl-Meyer Lower Limb (FMLL) 3) including only studies of sufficiently high methodological quality, >6 on Cochrane risk of bias tool).	N=955 total, across 32 studies. 13/32 met a priori criterion on methodological quality. MI predominantly compared to conventional or traditional therapy. Number of sessions and minutes per session varied. Variety of internal/external imagery strategies across studies. According to pre-determined groups, 5 studies assessed ADL, 7 assessed balance, 12 assessed gait/lower limb and 20 assessed upper limb. Some studies excluded from MA in each group due to lack of data. Analysis 1): favoured intervention for Balance, gait and upper limb, not ADL; studies highly heterogenous Analysis 2) favoured intervention for balance on Functional Reach test, but not Berg Balance. Favoured intervention for TUG and gait speed. Favoured intervention for upper limb on ARAT and	**+** Inclusion criteria not immediately discernible but present throughout text sections in methods. Authors acknowledge did not use EMBASE (nor AMED, CINAHL) but not further justified. PUBMED and others used. Researchers involved in data extraction not entirely clear. Otherwise a well-conducted review, so scored as acceptable. Note meta-analysis on small numbers of studies due to pre-determined groupings

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					FMUL, with lower heterogeneity. Analysis 3): all studies investigating ADL met quality criterion but with no significant differences. No difference either for gait/LL or UL in this group. No balance studies met quality criterion.	
416	A. Herranz-Gomez et al. (2020). Effectiveness of motor imagery and action observation on functional variables: An umbrella and mapping review with meta-meta-analysis. *Neuroscience and Biobehavioral Reviews,* 118: 828-845	Umbrella and mapping review with meta-meta analysis To determine the effectiveness of motor imagery (MI) and action observation (AO) on stroke patients (1)Arm function (2)Arm ADLs (3)Balance (4)ROM (5)MS Strength (6)Gait mobility Subjects: >18 asymptomatic or dx with msk, neuro or resp disorder.	MI or AO in isolation or combined with other treatments vs control.	Arm function Arm performance in ADLs	Arm function, 13 studies, 8 in meta-analysis. AO: 3 studies had statistically significant diff, MI: 10 studies, 9 had positive statistically significant. Overall large effect size for stroke patients (SMD =1.05, 95% CI 0.50-1.60 p<0.0001)	++ High quality review but the included studies were of low quality. No clear consensus on duration and frequency of intervention.
416	A. Herranz-Gomez et al. (2020). Effectiveness of motor imagery and action observation on functional variables: An umbrella and mapping review with meta-meta-analysis. *Neuroscience and Biobehavioral Reviews,* 118: 828-845	Mapping and umbrella review with meta meta analysis to synthesize and critically evaluate evidence of motor imagery and action observation on functional variables. Included adults with MSK, neurological or respiratory disorders. Systematic reviews of RCT's or controlled clinical trials.	Interventions included motor imagery or action observation conducted in isolation, in conjunction or combined with other treatment techniques. If combined, the control group must perform the other interventions.	Outcomes included postural balance, range of motion, muscle strength, arm function, arm performance of ADL and gait mobility.	18 systematic reviews (n=3312) were included of which 8 were included in meta-analysis. 2 relevant meta analyses: arm function and arm performance in ADL. 13 SR on patients with stroke. MA showed large effect size for arm function and performance in ADL in patients with stroke. Significant heterogeneity in methods.	Overview not just with patients with stroke but possible to separate these out in the reporting. Adequate quality.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
421	N. D. Lopez et al. (2019). Motor imagery as a complementary technique for functional recovery after stroke: a systematic review. *Topics in Stroke Rehabilitation,* 26:8 576-587	Systematic review. Spain. Two reviewers Randomized clinical trials investigating MI as a complementary technique for functional recovery after stroke. 13 RCT Sample size =36 Single stroke (acute (1), subacute (7), Chronic (6). Age range 18-92. Used Movement imagery questionnaire-revised.	Graded Motor Imagery combining Implicit, Explicit Motor Imagery and MT. Protocols: most frequent duration 6 weeks, 3-5 sessions a week. All combined MI applied after rehab session. Duration 5-25 mins. All studies (except 1) combined MI with other rehab approach in sessions lasting 11 min	Outcome measures used obtained pre-and post-intervention. Heterogeneous. 3 studies carried out follow up assessments at 2 weeks, 4 weeks and 3 months. FMA ARAT Jebsen Taylor Test Secondary: TUG, FMA LL, RVAG< Kinematics parameters of gait, COPM. Berg Balance.	MI used as a compliment combined with other therapies (task –orientated training) revealed statically significant improvements in ARAT and FMA (page et al) – with follow up at 10 weeks and 12 weeks post intervention.	**+** Articles with acceptable evidence to conclude that MI with other rehab techniques (as an adjunct) or technique to improve motor capacity of subjects who have suffered a stroke. No consensus about the protocol of MI intervention. small sample size. Still no clear conclusion on whether the application of MI should be performed in first or third person.
423	T. C. Machado et al. (2019). Efficacy of motor imagery additional to motor-based therapy in the recovery of motor function of the upper limb in post-stroke individuals: a systematic review. *Topics in Stroke Rehabilitation,* 26:7 548-553	Subject: 18+ stroke Design: RCTs Setting: Various 4 studies (1 not included in Barclay SR: Liu) Total 104 subjects, mean age 57.	Intervention: Motor imagery with motor-based therapy Dose variety (MP): 20 – 60 mins, for 3-10 weeks with 3-7 sessions a week. Content and delivery varied. Comparison: control group with motor-based therapy alone	Arm Functional Test-Functional Ability Scale (AFT-FAS), Arm Functional Test-Time (AFT-T), Action Research Arm Test (ARAT) Fugl-Meyer Assessment-Upper Extremity component (FMA-UE), Motricity Index of the upper extremity (MI-EU), Wolf Motor Function Test (WMFT)	Both experimental & control groups in the 4 studies showed stat sig improvement. However, experimental groups with MP showed stat sig results superior to the control in gross upper limb motor function (FMA-UE & MI-UE). 3 Studies evaluated WMFT, ARAT, AFT-FAS & AFT-T. Both groups in all 3 studies showed stat. sig improvement but only 1 (Riccio) demonstrated stat sig difference between groups.	+ Young sample and not the most comprehensive SR available but doesn't make claims based on inferential stats like Barclay does. "Suggest potential beneficial effects of MI associated with motor-based therapy in the recovery of upper limbs motor function post stroke" Comparison of studies suggest dose response (60 mins favourable to 20 or 40 mins)
423	T. C. Machado et al. (2019). Efficacy of motor imagery	Systematic review of MI as an adjunct to motor therapy.	MI defined by two methods. The kinesthetic: in which	Primary outcomes across studies were:	All studies suggested improved motor scores with	- Borderline acceptable

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	additional to motor-based therapy in the recovery of motor function of the upper limb in post-stroke individuals: a systematic review. *Topics in Stroke Rehabilitation,* 26:7 548-553	4 studies identified (total of 104 participants included) from a possible 14 studies (10 excluded) PICOS strategy incl: over 18, after ischemic or heam stroke. MI with motor based therapy. RCTs. Included studies were PEDro rated (scoring bw 5-7).	individual performs a mental simulation trying to feel the movement without this occurring. The visual: the individual visualizes the movement being performed by another person or by segments of his own body Two studies used both one used kinesthetic, one didn't state.	FMA, WMFT, ARAT, MI-UE (motoricity index), AFT (Arm Function Test?)	no notable improvement in ADLs suggested.	No mention of conflicts noted. Bias not discussed. Authors did make efforts to present chosen studies clearly however the synthesis was limited.
425	K. B. Monteiro et al. (2021). Effects of Motor Imagery as a Complementary Resource on the Rehabilitation of Stroke Patients: A Meta-Analysis of Randomized Trials. *Journal of Stroke and Cerebrovascular Diseases,* 30:8 105876	This systematic review and meta-analysis aimed to assess the effect of Mental Imagery, performed complementary to other interventions, on motor function and functional independence. Eligibility criteria: RCTs that analyzed individuals with stroke of any etiology and at any stage. The RCTs of patients affected by stroke and had motor function and functional independence as outcomes.	Motor imagery as a complementary resource in the Rehabilitation that included virtual reality, conventional rehabilitation, or traditional physical and/or occupational therapy. Electromyography-triggered electrical stimulation and Chinese acupuncture The training frequency varied between 2 to 5 times per week, with a total of 30 to 180 minutes of training, for 3 to 10 weeks.	FMA Gait speed	10 small RCTs with 278 post-stroke patients (141 in the experimental group and 137 in the control group) were included. 7 studies had upper limb FMA outcomes (n=101pts). Protocols were very varied and the quality ratings and risk of bias was also varied. Of the seven upper limb only studies only 1 was rated as high quality and low bias and it was the poorer quality studies that came out on the positive side of the forest plots. There was a GRADE assessment of the level of evidence, however the majority of high quality, low bias studies were Lower limb/gait and the GRADE	**+** While this SR and meta-analysis was conducted well the evidence they reviewed for the upper limb was poor quality and I think their interpretation of the results was over optimistic.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					assessment was not subdivided by limb (of the FMA assessment for evidence level includes lower limb). So while the authors concluded the MI was effective as an adjunct for improving motor function I think their conclusion for upper limb is over optimistic.	
425	K. B. Monteiro et al. (2021). Effects of Motor Imagery as a Complementary Resource on the Rehabilitation of Stroke Patients: A Meta-Analysis of Randomized Trials. *Journal of Stroke and Cerebrovascular Diseases,* 30:8 105876	A SR and meta-analysis of RCTs that used motor imagery as a complementary resource to rehabilitation. Population: patients affected by stroke Intervention: MI Outcome: motor function and functional Included studies were published after 2015.	Quality was assessed using the Jadad scale. Risk of bias was assessed using the Cochrane tool.	Any motor function outcomes (FMA was often used for the UL).	10 RCTs were included n=278; time since stroke was between 1 and 12 months. MI was undertaken with virtual reality, usual care and electrical stimulation. Freq was between 2 -5 times a week and between 30-180 minutes over 3-10 weeks. 6 studies had good quality, 4 had low quality.. 4 studies had a low risk of bias, 5 had uncertain risk of bias and 1 had a high risk of bias. Meta analysis showed an effect size of 2.32 (-1.19-5.83) on the FMA with a reported relative risk of 1 indicating no significant benefit over conventional therapy. High heterogeneity in included studies.	- Not clear who selected and data extracted the papers, how publication bias was considered, excluded studies were not listed.
429	K. Song et al. (2019). Mental practice for upper limb motor restoration after	Meta-analysis of randomized controlled trials. Investigated whether MP is a better management than other	Mental practice alone and mental practice combined with other treatments.	FMA and ARAT.	MP brought about a greater increase on both the FMA and ARAT on upper limb motor restoration after stroke.	**+** Some unknown sources of heterogeneity may have

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	stroke: an updated meta-analysis of randomized controlled trials. *Topics in Stroke Rehabilitation,* 26:2 87-93	conventional rehabilitation exercise for patients with stroke on upper limb motor restoration. 12 randomized controlled trials were included. Quality of the RCT's was evaluated using Cochrane risk assessment tool. Total of 268 patients. Study set in China.			MP therapy is recommended as adjunct therapeutic strategy to change the prognosis of stroke.	affected the results of the meta-analysis. Demographic characteristics such as age and race are not very complete.
429	K. Song et al. (2019). Mental practice for upper limb motor restoration after stroke: an updated meta-analysis of randomized controlled trials. *Topics in Stroke Rehabilitation,* 26:2 87-93	Systematic review with updated meta-analysis. Randomised controlled studies. Participants with stroke, in randomised studies exploring effects of mental practice (MP).	No detail of type or MP strategy in inclusion criteria. Experimental group= MP or MP combined with other treatment. Control = other exercise	Fugl Meyer Assessment ARAT. Methodological quality assessed using Cochrane risk of bias tool. All assessments of bias and data extraction by two reviewers and referred to third if disagreement. Heterogeneity and publication bias formally assessed.	12 studies met criteria and were included, n=268 participants. All assessed as moderate quality. Limited narrative synthesis element as such, just presentation of meta-analysis. Favoured experimental group for FMA, (fixed effects as low heterogeneity) and for ARAT (random effects as significant heterogeneity). Publication bias assessed, none detected with Egger's test.	+ Not clear why searches not re-run pre-publication- seems to be two-year gap; majority of studies USA or Korean in origin. Returned different studies to another review of similar question in similar timeframe (683)? Limited attention paid to implications of bias assessment. Scores well on other criteria.
430	R. C. Stockley et al. (2021). Systematic Review and Meta-Analysis of the Effectiveness of Mental Practice for the Upper Limb After Stroke: Imagined or Real Benefit?. *Archives of Physical Medicine*	SR and MA 10 databases, 15 studies, 12 in MA. Stroke patients. 4 early sub-acute 2 late sub-acute 8 chronic Mild or no cog deficits.	RCT using mental practice (MP) for the UL vs usual care, conventional therapy, no treatment.	(i)Activity limitations of the UL. (ii) When and who would benefit most (iii) if and how the dose affects the effectiveness	MP superior to usual care (SMD 0.6, 95% CI 0.32-0.88) MP most effective in first 3/12 post stroke (Weighted mean diff 7.33 95% CI 0.94-13.70) followed by chronic phase (SMD 0.09 95% CI 0.32-0.99). Subacute was non-significant. MP most beneficial for those with severe arm limitations	+ Acceptable quality.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	and Rehabilitation, 102:5 1011-1027				(ARAT 0-20)(WMD: 7.33 95% CI 0.94-13.72) followed by those with moderate limitations (ARAT 21-40) (WMD 5.13 95% CI 2.88-7.39) No effective in those with mild UL deficit. A lower dose (<6.6 min/day) appeared to be better (SMD 0.89 95% CI 0.04-1.74) than medium or high dose.	
430	R. C. Stockley et al. (2021). Systematic Review and Meta-Analysis of the Effectiveness of Mental Practice for the Upper Limb After Stroke: Imagined or Real Benefit?. *Archives of Physical Medicine and Rehabilitation,* 102:5 1011-1027	Systematic review: effectiveness of mental practice on outcomes of activities and activity limitations; when and in whom might MP have most benefit, if and how dose affects effectiveness. Participants over 16 with confirmed diagnosis of stroke with sensorimotor UL involvement	MP intervention to conventional therapy, usual care, placebo or no therapy.	Outcomes that measured UL activities before and after the intervention.	15 studies included for narrative review, 12 suitable for meta-analysis. SMD for activity limitations 0.6 (.32-.88) n=328, I2 29%. Largest benefit in early subacute period after stroke (7 days to 3 mo) and then chronic (>6 mo); participants with mild cog difficulties; participants mostly with moderate arm limitations. MP greatest benefit for those with most severe UL limitations (ARAT 0-20) (WMD 7.33; CI .94-13.72, 3 studies, n=82). Followed by mod limitation. Not effective in mild UL impairment (1 study) Results based on mod-high quality trials.	Adequate quality.
417	E. K. Ji et al. (2021). Graded motor imagery training as a home exercise program for upper limb motor	RCT based in Korea. Stroke over 3 months since onset. MMSE score >24. 47 right-handed subjects recruited with first ever stroke.	Graded MI involved implicit motor imagery, explicit motor imagery, and mirror therapy.	All subjects were tested at baseline, 4 weeks and 8 weeks. No follow up data.	37 completed an 8 week programme. (5 dropped out). All subjects showed improvement in the MFT ,	- Small sample size. Can't say if randomisation is mentioned method not specified.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	function in patients with chronic stroke: A randomized controlled trial. *Medicine,* 100:3 e24351	Ran Excluded 5 not meeting inclusion criteria. Randomised n=42. Allocation : conventional therapy with graded MI =21 and Coventional therapy n=21.	Performed at home over 8 weeks (30mins a day). All 3 tasks were repeated 3 times with into session rest. Both groups received conventional therapy (task-oriented active/passive, weight support, stretching grasoing holding and placing objects.	Primary outcome Manual Function Test (MFT) and FMA. Secondary outcome measure was change in ADL Korean version of the Barthel Index.	FMA (not MCID only 2 points) and MBI	Allocational concealment isn't clear. Presence of blinding is not clear. No follow up outcome measures.
410	A. Azad et al. (2018). Effect of motor imagery training with sensory feedback on sensory-motor function of the upper extremity in patients with chronic stroke. *Journal of Babol University of Medical Sciences,* 20:9 28-35	Setting: Rehabilitation Centre(s?) in Iran Design: Non-randomised clinical trial (but states they were randomly assigned) Subjects: 30 stroke pts (MMSE 21+, Brunnstrom 2+) Mean age 68 (Control) 64 (Intervention) n=15 in each group Non-probability sampling (no details) No details re: chronicity of participants other than last words in discussion "chronic stroke".	Control: Conventional rehab (12 sessions over 4/52 x 46-60 mins) Intervention: Conventional rehab + Motor-imagery (MI) training with sensory feedback (12 sessions over 4/52 x 46-60 mins). Intervention group specifically focussed opposing synergistic activity patterns. Sensory feedback provided by examiner (? Through passive movement associated with MI)	Pre & Post: Box-Block test (BBT) Purde-Pegbord test, range of motion (ROM), Fugl-Meyer Assessment-Upper Extremity component (FMA-UE), 2-point-discrimination (2PD), Nottingham-Sensory Assessment (NSA), Modified-Ashworth Scale (MAS) Stroke Impact Scale (SIS)	Both groups improved across the board. Statistically sig between group differences in: ROM (shoulder abduction & elbow ext) BBT FMA-UE -in favour of intervention group	- Insufficient detail regarding sample, recruitment, blinding or intervention to be confident in drawing conclusions *Does not isolate effects of MI as intervention – this is used in conjunction with sensory feedback.
410	A. Azad et al. (2018). Effect of motor imagery training with	This trial compared two groups (control n=15; intervention n=15)	The intervention is only partly defined. MI consisted of	Outcomes measures included BBT, Perdue PB, Goniometry, MAS, 2Point	The authors report mean percentage of changes in motor function and	**0**

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	sensory feedback on sensory-motor function of the upper extremity in patients with chronic stroke. *Journal of Babol University of Medical Sciences,* 20:9 28-35	with chronic stroke (defined as within 6months) In addition to usual care the intervention group received MI combined with sensory feedback Recruited from rehab centres in Iran, unclear where the intervention was delivered. Incl criteria: having upper extremity function level 2 and above based on the Brunnstrom scale "spasticity appears"; MMSE greater than 21, lack of musculoskeletal problems that led to contracture and joint deformity, lack of unilateral neglect, lack of dementia and depression, lack of receptive-expressive aphasia, and the ability to read and write were included in the study.	kinesthetic (in which individual performs a mental simulation) exercises . This was provided in addition to usual care. "These exercises were performed for the important functions of the upper extremity against the tonic spasticity conditions… including: shoulder abduction, external shoulder rotation, elbow extension, forearm supination, wrist extension and flexion of the metacarpophalangeal joints of the fingers. Sensory feedback was also provided by the examiner according to the passive movement of the joints in the defined conditions according to MI exercises".	discrimination, NSA, SIS, FMA	speed/coordination of upper extremity, shoulder and elbow range of motion and gross dexterity was higher in the interventional group Do not feel the use of proportions accurately reflect the raw data presented and is misleading. Mean changes in FMA of 2 points are reported as statistically significant despite likely large variance in the underlying sample and raw data suggesting limited difference between groups (as well as not meeting the threshold for MDC or MICD). Similar measures of significance are ascribed to other measures such as BBT	The study is described as non-randomised in the abstract but refers to randomisation in the paper with no subsequent detail There is no reference to any blinding or baseline outcomes being completed by an independent assessor The lack of methodological detail, size of the study, lack of clarity regarding randomisation and lack of blinding make this study unacceptable for consideration
427	A. Poveda-Garcia et al. (2021). The Association between Mental Motor Imagery and Real Movement in Stroke. *Healthcare*	Spanish Cohort study looking at the relationship between the ability to create mental images and the ability to move. Small sample size: 39 stroke patients, divided into two groups according to their ability to	Independent variable the ability to create mental images of movement or actions according to CEMIMA questionnaire.	dependent variables FMA, hand function measures, grip strength and cognitive impairments. FMA-UE (split into 8 scores)	The results indicate high correlations between MI and movement on the FMA, and hand function measures; moderate correlation of MI with cognitive measures of	**0** The study was small for a cohort study, there was no mention of sample size or power calculation, but with the number of variables included I

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	(Basel, Switzerland), 9:11	create mental images (MI) Group 1 poor ability to visualise; group 2 better ability to visualise based on score on CEMIMA: Mental evoking images, movements and activities questionnaire. Also divided according to time post stroke<6 months and >6 months. Inclusion criteria: -18 years old; -ischemic or hemorrhagic stroke, no time limit -Medically stable and can attend therapy; -able to give informed consent. Exclusion criteria: -previous pathology in their UL, traumatic, neurological, or any other type of pathology that may affect the results of the assessment; -reported some neurological alteration before the stroke; -Severe aphasia, memory disorders, attention disorders, visual and communication disorders, or other neural symptoms, which may interfere in the study.		ABILHAND JHFT 9-HPT Dynamometry Zoo map test Block design Digit span.	block design and visuo-spatial ability. The group with better MI had statistically significant better movement. The authors also looked at the factor of time since stroke and found MI was statistically significantly worse in those with stroke over 6 months.	would expect it to need a much larger sample. The details needed to make this a high-quality study were missing from the report e.g.: Number of participants eligible; numbers per group; assessor blinding to the independent variable scores.
427	A. Poveda-Garcia et al. (2021). The Association between Mental Motor Imagery and Real Movement in Stroke. *Healthcare (Basel, Switzerland),* 9:11	Observational study to examine association between MI and UL movement. Setting: Hospital in Spain. N=39. Participants were either within 6 months of their stroke or after six months. Mean age was 66.2 (range 49 to 84 years old, SD = 9.88). All	No intervention – participants completed a battery of UL tests and ADL and cognitive measures which were compared to a questionnaire which measures to the	UL: Fugl Meyer UE, ABILHAND scale, 9 hole peg test, Jebsen Hand function test, grip strength dynamometry. ADL:Barthel Index and Lawton IADL scale. Cognition: Digit span test,	Participants were split into two groups based on their CEMIMA results (poor visualising and good at visualising). Between these two groups there were significant differences in all UL measures on the BI (but not	No Formal checklist for this type of study but weaknesses include lack of blinding of assessor which may bias results and potentially some recruitment bias.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		the participants had suffered a stroke (19 ischemic and 20 haemorrhagic) 22 participants with left side affected and 17 with right side affected	ability to create mental images	block design zoo map test of the behavioural assessment of dysexecutive syndrome. Mental imagery ability: Mental Evoking Images, Movements and Activities Questionnaire (CEMIMA).	IADL) and on one cognitive test (block design) but not the others. There was a strong association (r>0.7) between CEMIMA scores and the FMA-UE, Jebsen Hand function test and ABILHAND tests. There was a moderate correlation (>0.5<0.7) between CEMIMA scores and 9 hole peg test, hand grip and block design cognitive test. There was a significant difference between those within 6 months of stroke and those after 6 months indicating those longer after stroke had more difficulty undertaking visualisation.	
432	W. Pan et al. (2019). The effects of combined low frequency repetitive transcranial magnetic stimulation and motor imagery on upper extremity motor recovery following stroke. *Frontiers in Neurology,* 10:0 96	Single-blinded randomized controlled trial. Trial studied low frequency transcranial magnetic stimulation (LF-rTMS) combined with motor imagery on upper limb function Study set in China. Patients had an ischaemic stroke, were inpatients and within three to twelve months from the onset of diagnosis. 42 patients in the study.	Two intervention cohorts – experimental group was applied 1Hzr transcranial magnetic stimulation over the primary motor cortex of the contralesional hemisphere combined with audio based motor imagery and the control group received the same therapeutic parameters of transcranial magnetic stimulation combined with audiotape-led relaxation.	Wolf Motor Function Test, Fugl-Meyer Assessment, Box and Block test and modified Barthel index conducted at baseline, week two and week four.	LF-rTMS combined with mental imagery had a positive effect on motor function of the upper limb.	**+** Acceptable study. Single centre trial. Small sample size. No follow up to see long term benefit.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			Treatment conducted in 10 sessions over two weeks for 30 minutes.			
432	W. Pan et al. (2019). The effects of combined low frequency repetitive transcranial magnetic stimulation and motor imagery on upper extremity motor recovery following stroke. *Frontiers in Neurology,* 10:0 96	Randomised study, single blind, two intervention groups. Rehabilitation hospital, Shanghai. Participants were people within 3-12 months of ischaemic stroke, no previous upper limb impairments. Aged 21-80 with mini mental state exam of 23 or more.	Random assignment to one of two groups: -rTMS + MI group: TMS over primary motor cortex contralesional hemisphere,1Hz with audio-based MI. -rTMS same parameters plus audio-tape relaxation. 10 sessions, over 2 weeks, 30 minutes. Equal doses conventional rehabilitation each group- 120 mins per day for ten sessions, general rehab with no MI.	Primary outcome-Wolf Motor Function test WMFT. Secondary measures- Upper Extremity-Fugl-Meyer Assessment (UE-FMA) subscore, Box and Block (BBT) and Modified Barthel (MBI) Measured at baseline, week 2 (end intervention) and week 4 (follow-up)	N=44 people randomised. 2 in rTMS group did not receive allocated intervention, dizziness., n=42 in end analysis. Significant between group difference on WMFT at 2 and 4 weeks. Similarly on secondary measures MBI, UE-FMA and BBT at weeks 2 and 4. Recovery within groups demonstrated on all outcomes, greater in rTMS+MI than rTMS alone.	**++** Well-designed study. No sample size consideration and small groups impact generalisability of findings but further research into such combined approaches indicated.
426	S. J. Page & P. Levine (2021). Multimodal Mental Practice Versus Repetitive Task Practice Only to Treat Chronic Stroke: A Randomized Controlled Pilot Study. *The American journal of occupational therapy : official publication of the*	RCT (secondary analysis) Outpatient rehab lab n=18 chronic stroke patients 18-75 with moderate UL impairment. 10o active flexion of wrist and 2 digits, MMSE >24. Excluded if MAS >2, pain >4/10, parietal stroke.	Repetitive task practice (RTP only) Vs Multimodal mental practice (MMMP) = Repetitive UL task practice, active observation, mental practice.	Pre / post test: ARAT UE Fugl Meyer Stroke Impact Scale – Hand subscale.	MMP had a significantly larger increase in all three outcomes (p<0.01) and surpassed the minimal clinically important difference for all three outcomes.	- Low quality due to pilot study with small sample size, no information on concealment or blinding but promising results. Larger study needed.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	American Occupational Therapy Association, 75:6		Both interventions were 45 mins OT 3/7 for 10/52.			
426	S. J. Page & P. Levine (2021). Multimodal Mental Practice Versus Repetitive Task Practice Only to Treat Chronic Stroke: A Randomized Controlled Pilot Study. *The American journal of occupational therapy : official publication of the American Occupational Therapy Association,* 75:6	Setting: Outpatient clinical rehab laboratory. Design: Secondary analysis of RCT pilot study data. Subjects: 18 (9 per group) chronic stroke survivors with moderate, stable upper limb impairment.	Repetitive task practice (45 mins OT 3 x per week) compared with mental practice time matched incl. action observation, repetitive task practice, and mental practice in 15 min increments.	ARAT; UL fugl-meyer; and hand subscale of stroke impact scale 1 week before and 1 week after intervention.	Mental practice group showed significantly larger increases on all three outcome measures and surpassed minimal clinically important difference for all three outcomes.	Adequate quality. Small numbers, assessors but not participants blinded, RTP group more chronic (3.1 years cf 1.9 years for MP). More R. side affected in RTP group.
419	H. Kim et al. (2018). The effects of mental practice combined with modified constraint-induced therapy on corticospinal excitability, movement quality, function, and activities of daily living in persons with stroke. *Disability and rehabilitation,* 40:20 2449-2457	RCT? Dept of OT Korea. 14 participants' aim of the study: compares the difference in the effects of MP combined with mCMIT against mCIMT alone. Inclusion criteria : stroke >3months. MMSE >24Vividness of movement imagery questionnaire. Brunnstrom's hand function recovery stage >3 and MCP extension 10 degree & wrist 20degrees.Participants blinded to which group they were allocated. 14 (2 drop outs) participants. Experimental gp: mCMIT and MP 10 sessions 2 weeks. Control gp: CIMT. Homogeneous groups.	Experiential group participated in both mCIMT and MP. Control group mCIMT. mCIMT programme requires all participants to perform their ADL while wearing a hand constraint. For 6 hours 5 days a week for 5 weeks. Supervisied by an OT. MP programme coupled with action observation listening to audio material	3D motion analysis, Jebsen -Taylor hand function test, motor activity followed by MEP.	3D motion analysis=no difference between groups. Jebsen -Taylor hand function=Experimental group-no statistically significant change. Motor activity log: statistically significant increase in ADL scores.	Sample size too small. Intervention period too short.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			while watching video for 10 min. MP performed right after one hour repetitive ADL training. Control group: 10 min of classical piano music.			
418	J. H. Kang et al. (2021). The effects of additional electrical stimulation combined with repetitive transcranial magnetic stimulation and motor imagery on upper extremity motor recovery in the subacute period after stroke: A preliminary study. *Medicine,* 100:35 e27170	Setting: Rehabilitation department (?inpatient) Korea Design: Single blind RCT Subjects: Control n=9 Intervention n=8	Control: Low frequency repetitive transcranial stimulation (LFrTMS) + Mental Imagery (MI) + sham electrical stimulation (ES) +conventional rehabilitation. Intervention: LFrTMS + MI + active ES + conventional rehabilitation. Both groups received 10 sessions over 2/52.	Pre and post: Fugl-Meyer Assessment-Upper Extremity component (FMA-UE), Shoulder abduction & finger extension scores, modified Barthel Index (mBI), Purdue Pegboard Test, Finger tapping test	Stat sig difference in both groups for mBI & FMA-UE. Significant between group difference for FMA-UE in favour of intervention. No mention of intention to treat analysis (3/20 dropped out).	Acceptable but borderline as small sample and lack of ITT. Ultimately doesn't isolate MI as an intervention so does not contribute to this question.
418	J. H. Kang et al. (2021). The effects of additional electrical stimulation combined with repetitive transcranial magnetic stimulation and motor imagery on upper extremity motor recovery in the	Single blind RCT. Rehab department in Korea. Compared two groups with first ever subacute stroke (defined as with 1wk-3mths). Age ≥ 20years. MMSE ≥20. Two-week intervention: -Experimental (n=8): Electrical Stimulation+rTMS+MI	Primary intervention was ES in the hemiplegic UL (1ms/10Hz or Sham) Low Freq rTMS received by both groups: Fig 8 coil, 1200 pulses over 20min at 1Hz over	Outcomes by blinded Assessor at: -Baseline (day before treatment) -Post (immediately after 2wk treatment Primary FMA	Within group differences showed some signal: -Intervention group improved FMA by 11.75±9.11 -Sham ES group improved FMA by 3.67±3.67	**+** Acceptable. The primary variable under investigation is not relevant to Q32. This is a reasonably designed pilot study investigating ES.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	subacute period after stroke: A preliminary study. *Medicine,* 100:35 e27170	-Control (n=9): Sham ES+rTMS+MI Both groups: 5/7, 2/52 (10 sessions) each session followed by OT. Conventional rehab same in both groups.	contralesional M1 (90% resting threshold) MI received by both groups: 20 min structured Audio session (4 parts) -Imagination prep -MI warm up (movnts) -Imagining ADL's -Cool down	Secondary SAFE Barthel PerduePB Finger tap test		The sample is too small to draw any conclusions.
431	Q. Wu et al. (2021). Analysis of Prognostic Risk Factors Determining Poor Functional Recovery After Comprehensive Rehabilitation Including Motor-Imagery Brain-Computer Interface Training in Stroke Patients: A Prospective Study. *Frontiers in Neurology,* 12: 661816	Chinese prospective cohort study of 73 stroke patients who had rehabilitation including motor imagery brain computer interface training <6 months post onset, to determine prognostic factors of hand movement recovery. The sample was divided into 2 groups for analysis: Group IG recovery ≤2 change on FMA(wrist hand WH); group EG >2 change in FMA WH score	Rehabilitation including Occupational Therapy and MI using a brain computer interface.	FMA scores for wrist and hand.	Those with poor recovery of ≤ 2 points change on the FMA (WH) and those who improved >2 points. The results indicate that the group with poorer recovery had recovery significant hand spasticity, poor initial function and aphasia.	**+** However, this study does not answer the question and I'm not sure that it provides findings that would be helpful for any recommendations we already know that those with poorest hand movement initially are less likely to recover hand movement. All this is saying is that MI is unlikely to make any difference to that. You cannot change the damage to the corticospinal tract with MI.
431	Q. Wu et al. (2021). Analysis of Prognostic Risk Factors Determining Poor Functional Recovery After Comprehensive Rehabilitation Including Motor-Imagery Brain-	Prospective study of 82 inpatients in China (n=73 with complete data); age =61 years, 3 months post stroke) who all received conventional therapy and mental imagery with brain computer interface (CRMI-BCI) to determine factors that may be	Intervention combined conventional rehab (1 hours/day, 5 days /week for 4 weeks) with mental imagery undertaken with BCI which comprised 20 sessions over 4 weeks	FMA-UL, modified Ashworth scale for muscle tone for finger flexors. Group dichotomised into those that improved their FMA wrist and hand score by 2 points or more after the intervention.	All patients showed a significant improvement in FMA scores after treatment. Presence of aphasia, increased tone (1+ and above on MAS) and poorer FMA UL scores (think this is 34 in effective group vs 25 in ineffective group average scores) pre	Some assessor blinding evident. Quality likely to be acceptable.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Computer Interface Training in Stroke Patients: A Prospective Study. *Frontiers in Neurology,* 12: 661816	associated with a poor UL recovery after this treatment.	(5 sessions/week). MI-BCI intervention During each session, the patient was comfortably seated in a soundproofed room, with their affected hand resting in an exoskeleton hand. A video of the unaffected hand grasping/opening was presented on a screen in front of the patient to guide the MI task of gripping or opening their hand. They watched the hand grasp or hand open for 6 seconds. The exoskeleton hand provided mechanical support and assistance to the affected hand based on the mu suppression algorithm. Thye completed 100 reps per session		training were likely to be associated with poor recovery of hand function after training. Should laos be noted that the less effective group (IG) containted significantly more peoapls who had a stroke more than 6 months ago.	
424	S. Mansour et al. (2022). Efficacy of Brain-Computer Interface and the Impact of Its Design Characteristics on Poststroke Upper-limb Rehabilitation: A Systematic Review and Meta-analysis of	Systematic review and meta-analysis of randomized controlled trials. Investigation of the effectiveness of different brain computer interface on post stroke upper limb rehabilitation. Study included twelve clinical trials involving 298 patients.	Nine studies instructed the BCI group to imagine the movement of the affected hand and three studies asked the BCI group to attempt to move the affected hand.	Fugl-Mayer assessment before and after the intervention.	Meta-analysis confirmed the effectiveness of brain computer interface for upper limb rehabilitation.	**+** Study is not just visual imagery (only 9 out of the 12 studies). Different types of BCI feedback in the studies e.g FES, hand exoskeleton, MIT-Manus robot, haptic knob, assisted soft

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Randomized Controlled Trials. *Clinical EEG and Neuroscience,* 53:1 79-90	Study set in Sheffield and Singapore.	Different types of BCI feedback in the studies e.g FES, hand exoskeleton, MIT-Manus robot, haptic knob, assisted soft robotic glove.			robotic glove and orthosis was used. Insufficient number of clinical trials studied. No clear treatment programme of the mental imagery patients.
424	S. Mansour et al. (2022). Efficacy of Brain-Computer Interface and the Impact of Its Design Characteristics on Poststroke Upper-limb Rehabilitation: A Systematic Review and Meta-analysis of Randomized Controlled Trials. *Clinical EEG and Neuroscience,* 53:1 79-90	Systematic review and meta analysis of short and long term effects of Brain Computer Interfaces (BCI) on upper limb rehabilitation in people with stroke. Included RCTs of upper-limb BCI rehabilitation after stroke, that reported Fugl-Meyer Upper Extremity assessment (UE-FMA) before and after intervention, and were written in English.	BCI rehabilitation for the upper limb. Detail of 'usual' components of BCI for stroke given in introduction. Exact search terms available as Appendix but not in main text. Checked in online supplementary material, intervention terms 'brain computer interface' or 'brain machine interface' only.	UE-FMA main outcome. Methodological quality of included studies assessed using PEDro risk of bias tool. Study selections and assessments of bias and done by two reviewers and referred to third if disagreement. Calculated effect sizes for pooled and individual studies (Hedge's equation). Random effects models used due to heterogeneity, and publication bias assessed vie Eggers	N=12 studies met criteria, number of participants across studies not clear. All scored 6 and above on PEDro. BCI intervention significantly more effective than control immediately after intervention, significant heterogeneity, no evidence of publication bias (Hedges g 0.73 p=0.006); and also in long term and with no heterogeneity (Hedges g 0.33, p=0.041). BCI mental practices different across studies, as were BCI features used.	**+** Whether two researchers involved in data extraction not entirely clear. Details of MI/practice protocols in included not clear enough to support clinical recommendation. No detail on unpublished literature. Well-conducted review as presented despite above challenges.
428	M. Sebastian-Romagosa et al. (2020). Brain Computer Interface Treatment for Motor Rehabilitation of Upper Extremity of Stroke Patients-A Feasibility Study. *Frontiers in*	Feasibility study, pre-post. N=51 stroke patients with UL hemi, able to follow written and verbal instructions, stroke >4 days pre ax.	25 sessions of motor imagery with a brain computer interface system, sessions were 2/7 for 3/12.	Primary: Fugl Meyer UE Secondary: MAS, 9HPT, Box and Block Test, BI, Fahn Tremor Rating Scale, Two point discrimination test, MOCA, Self-rated questionnaire	FM UE significantly improved post intervention (p<0.0001) but this was not maintained at 1/12 and 6/12. MAS significantly reduced in the fingers and wrist (p<0.001) No sig changes in other OMs.	Low quality study as no control. Insufficient evidence to support intervention in the longer term.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	Neuroscience, 14: 591435			Outcomes were complete pre ax at 1 month and few days pre ax and post intervention, 1/12 and 6/12 post intervention.		
428	M. Sebastian-Romagosa et al. (2020). Brain Computer Interface Treatment for Motor Rehabilitation of Upper Extremity of Stroke Patients-A Feasibility Study. *Frontiers in Neuroscience,* 14: 591435	Setting: Outpatient clinical rehab laboratory. Design: Secondary analysis of RCT pilot study data. Subjects: 18 (9 per group) chronic stroke survivors with moderate, stable upper limb impairment.	Repetitive task practice (45 mins OT 3 x per week) compared with mental practice time matched incl. action observation, repetitive task practice, and mental practice in 15 min increments.	ARAT; UL fugl-meyer; and hand subscale of stroke impact scale 1 week before and 1 week after intervention.	Mental practice group showed significantly larger increases on all three outcome measures and surpassed minimal clinically important difference for all three outcomes.	Adequate quality: small numbers, assessors but not participants blinded, RTP group more chronic (3.1 years cf 1.9 years for MP). More R. side affected in RTP group.
422	R. R. Lu et al. (2020). Motor imagery based brain-computer interface control of continuous passive motion for wrist extension recovery in chronic stroke patients. *Neuroscience Letters,* 718: 134727	China. An observational study. 26 chronic stroke patients, with upper extremity motor impairment. All patients showed no wrist extension recovery. Age range 16 to 70 years old. Able to operate MI based BCI by imaging the movement of the paretic wrist. (EEG) system was used to acquire cortical signal while they were imagining extension of the affected wrist. Patients without consistent EEG signal patterns were excluded.	Patients received 6 week training 20 sessions in total. Each training session consisted of two parts, EEG-supervised training and BCI-driven CPM training. In the EEG-supervised training, the MI state of wrist extension was tested. In this 10-min training, one of the "↑", "↓" and "×" symbols would be randomly displayed on the screen to cue MI tasks of wrist extension,	Outcome measure: The increase of active ROM of the affected wrist from baseline to the end of the 6-week training. Secondary outcome measures (1) modified Barthel Index (modified BI); (2) EEG classification accuracy; (3) MI-induced EEG pattern of wrist extension.	21 patients completed the training sessions, 17 regained a certain degree of active wrist extension. No statistical difference between baseline and final evaluations in Barthel.	Small sample size. Preliminary Study.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
			wrist flexion or cease of imagining, respectively. Patients would stop training if the accuracy of EEG classification was less than 57 %.The BCI-driven CPM training consisted of four separate 10-min trials. Before started, the patient's affected upper extremity was fit on a CPM machine. The ROM of wrist was set from 30° flexion to 40° extension.			
420	A. Kruse et al. (2020). Effect of brain-computer interface training based on non-invasive electroencephalography using motor imagery on functional recovery after stroke - a systematic review and meta-analysis. *BMC Neurology,* 20:1 385	Setting: lab setting Design: Systematic review & Meta-analysis of Brain-computer interface Training (BCIT) Subjects: 14 RCTs (n=363) (3 non-UL specific which are not included in the metanalysis) Mean age 53 (+/- 5.8) Mean chronicity 15.7 months (+/- 18.2)	BCI training ranged from 3 days to 6 weeks, 2-3 sessions per week. These studies are dependent on high specification laboratory equipment that is not replicable within current resources.	Fugl-Meyer Assessment-Upper Extremity component (FMA-UE), Subgroup analysis for: Chronicity (+/- 6 months) Training intensity Duration Follow-up period	BCI training in addition to conventional therapy, compared to conventional therapy alone was effective: SMD of 0.39 (95%CI: 0.17 to 0.62; 95%PI of 0.13 to 0.66) for FMA-UE Covariates: training duration, UL impairment level (&combination) did not show significant effects on overall pooled estimate.	+ However how "Mental Imagery" is conceptualised does not align with the current guidance – I feel this is closer to closed loop visual feedback. Therefore, not relevant to this question. See link for details of architecture of the interface: https://www.researchgate.net/figure/Architecture-of-MI-based-brain-computer-interface-MI-BCI-for-upper-limb-robotic_fig1_225074218
420	A. Kruse et al. (2020). Effect of brain-computer interface training based on non-	Systematic review and Meta-analysis looking at BCIT motor and brain recovery.	The intervention is brain-computer interface training (which largely relies	Primary Outcomes in three domains: 1)UL Motor recovery	This analysis suggested BCI training	+ However the primary analysis does not relate to Question 32

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
	invasive electroencephalography using motor imagery on functional recovery after stroke - a systematic review and meta-analysis. *BMC Neurology,* 20:1 385	Included 14 studies (362 subjects) up to March 2019. PROSPERO Registered, PRISMA design, PICOS parameters. Incl cireteria were studies evaluating BCIT as intervention	on MI). Signals from MI are decoded and used to control computers or devices. This did not evaluate MI as an intervention	Incl: FMA, ARAT, MAS, Shldr Slxn, NIHSS 2)LL Motor recovery 3)Brain function recovery Secondary outcomes were subgroup analyses.. Subacute, intensity, duration, time-to-follow-up	compared to conventional therapy alone in patients after stroke was effective for motor function recovery of the upper extremity (FMA mostly) however the CI was approached zero closely.	
413	R. Carvalho et al. (2019). Brain-machine interface of upper limb recovery in stroke patients rehabilitation: A systematic review. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy,* 24:2 e1764	This is a systematic review of the use of Brain computer interface for upper limb recovery after stroke. 9 studies were reviewed qualitatively. All were assessed as high quality RCTs 233 participants included, average age range 49.3-67.1, time post stroke 1.7-71 months	There is no mention of mental imagery so it just seems to be neurofeedback on movement performance.	Upper limb function measures FMA used in 8/9 studies Others were: Manual function test Motor activity log ARAT Goal attainment scale Wrist ROM.	Mixed picture. Not quantified in a meta-analysis.	+ The main problem in assessing the results is the lack of meta-analysis to quantify effectiveness. Therefore do not think it adds to the evidence for this question.
413	R. Carvalho et al. (2019). Brain-machine interface of upper limb recovery in stroke patients rehabilitation: A systematic review. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy,* 24:2 e1764	Systematic review of brain-machine (BCI) interface for stroke. Databases: Pubmed, scopus, PEDro, dates: Jan 2010-Dec 2017. RCTs considered only. Published in English or Spanish. P: Adult stroke patients. Intervention BCI for upper limb movement with or without conventional therapy. Outcome: Upper limb function. Quality assessed on PEDro scale.	Intervention: BCI and MI.	Functional UL measures (e.g. FMA) and instrumental UL measures (grip strength)	04 articles were found. This was reduced to 26 for full text screening and 9 for inclusion, n=233. Age ranges from 49-67 years and were between 1.7 to 71 months after stroke. Near-infrared spectroscopy (NIRS)-based MI-BCI was used in 1 study in combination with occupational therapy and visual feedback information was displayed on a monitor, in comparison with sham neurofeedback 8 studies focused on	+ Acceptable. The quality assessment of the studies was not well used, and publication bias was not considered (although the paper did not undertake a meta analysis)

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
					EEG-based MI-BCI, all of which used non-invasive scalp EEG-based recordings. 1 study combined BCI with robotic feedback neurorehabilitation compared with standard robotic rehabilitation. 1 study used BCI Haptic Knob robotic feedback compared with Haptic Knob robot or standard arm rehabilitation. No meta analysis undertaken but findings suggest that MI with BCI appears (more) effective to improve UI function when compared to conventional therapy or robotic rehab. There is also suggests that it may normalise brain activation patterns. 3 studies included people with severe UL deficits who made significant improvements suggesting that MI/BCI could provide a useful rehab method for these patients.	
411	Z. Bai et al. (2020). Immediate and long-term effects of BCI-based rehabilitation of the upper extremity after stroke: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation,* 17:1 57	Systematic review and meta-analysis. Immediate and long term effects of brain computer interface technology. Eighteen single group studies and fifteen controlled studies were included. Average duration since stroke indicated that subjects were at chronic stages.	BCI training was administered across more than one session. BCI feedback devices used were upper extremity robot and arm orthosis, FES or visual feedback.	Fugl-Meyer assessment most common outcome measure. Two studies used the Manual Function Test and the Jebsen Hand function test.	BCI training has significant immediate effects on the improvement of upper extremity motor function. Limited number of studies does not support its long term effects. BCI's combined with FES may be a better combination for	**+** Studies have shown significant effects of BCI based rehabilitation on the upper limb but different use of mental tasks, feedback devices and clinical protocols.

Ref ID	Source	Setting, design and subjects	Intervention	Outcomes	Results	Evidence quality (SIGN checklist score) and comment
		Authors in Hong Kong, China and USA.			functional recovery than other kinds of neural feedback.	
411	Z. Bai et al. (2020). Immediate and long-term effects of BCI-based rehabilitation of the upper extremity after stroke: A systematic review and meta-analysis. *Journal of NeuroEngineering and Rehabilitation,* 17:1 57	Systematic review, to explore 1) immediate and long-term effects of BCI 2) differences in treatment effects for different BCI training paradigms 3) explore different effects of BCIs when combined with different external devices 4) explore potentiating effects of tDCS on BCI training. Included single group and controlled studies of adults with stroke and hemiparetic upper limb that aimed to evaluate BCI.	Studies aimed to evaluate the effects of BCIs on hemi- paretic upper extremity functional recovery. The control intervention could be sham BCI training or conventional training without BCIs. BCI training was administered across more than one session.	Upper extremity Fugl-Meyer, UE-FMA, mist common primary outcomes across studies. Methodological quality of included studies assessed using PEDro risk of bias tool. Study selections, data extraction and risk of bias carried out independently by two reviewers and referred to third if disagreement.	18 single group and 15 controlled studies included. Qualitative synthesis of single group studies and meta-analysis of controlled studies using mean change scores and SD. SMD with 95%Cis. Reviewer has focussed here on MI-based BCI as this question was specifically explored as one component of in this review- movement attempt based (SMD = 0.69; 95% CI = 0.16–1.22; I2 = 0%; P = 0.010; and action observation based (SMD = 1.25; 95% CI = 0.0.05–2.45; I2 = 72%; P = 0.040) BCIs showed superior clinical effects to MI based (SMD=0.16; 95% CI=−0.13 – 0.45; I2=0%; P = 0.290) in improving UE function with no publication bias found based on Eggers test.	**++** Complex review with a number of related aims, scored strongly across SIGN constructs so scored.