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Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury (Review)

Mitchell C, Bowen A, Tyson S, Butterfint Z, Conroy P

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[Intervention Review]

Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

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ABSTRACT

Background

Dysarthria is an acquired speech disorder following neurologic injury that reduces intelligibility of speech due to weak, imprecise, slow and/or uncoordinated muscle control. The impact of dysarthria goes beyond communication and affects psychosocial functioning. This is an update of a review previously published by another group in 2005 and has been broadened to include additional interventions.

Objectives

To assess the effects of interventions to improve dysarthric speech following stroke and other non-progressive adult-acquired brain injury such as trauma, infection, tumour and surgery.

Search methods

We searched the Cochrane Stroke Group Trials Register (May 2016). We searched CENTRAL (*2016*, Issue 4 of 12) and we searched the following databases on May 6th 2016: MEDLINE, EMBASE, CINAHL. We searched LLBA (1976 to November 2016) and PsycINFO (searched 1800 - September 2016). To identify further published, unpublished and ongoing trials, we searched major trials registers WHO ICTRP (http://www.who.int/ictrp/search/en/), the ISRCTN registry (http://www.isrctn.com/), ClinicalTrials.gov (http://www.clinicaltrials.gov/) and the Stroke Trials Registry (www.strokecenter.org/trials/). We also handsearched the reference lists of relevant articles and contacted academic institutions and other researchers regarding other published, unpublished or ongoing trials. There were no language restrictions.

Selection criteria

We selected randomised controlled trials (RCTs) comparing dysarthria interventions with (1) no intervention, (2) another intervention for dysarthria (this intervention may differ in methodology, timing of delivery, duration, frequency or theory), (3) an attention control.

Data collection and analysis

One author (CM) independently screened all titles, three authors (CM, AB, PC) then independently screened remaining abstracts, examined full text studies for possible inclusion and discussed these where necessary, extracted data and assessed risk of bias. We reconciled differences by discussion or through an independent arbitrator. No author reviewed their own study. We contacted study authors for clarification and missing data. We calculated a standardised mean difference (SMD) and 95% confidence interval (CI), using a random-effects model and performed sensitivity analyses to assess the influence of methodological quality and planned subgroup analyses for underlying clinical condition.

Main results

We retrieved 17,313 citations, identified two ongoing trials and included five small trials that randomised 234 participants. Two studies had low risk of bias and none of the included studies were adequately powered. Two studies used an attention control and three studies compared to an alternative intervention, which in all cases was one intervention versus usual care intervention. There are no trials of an intervention versus no intervention. There are no trials of the same intervention with variations in timing, dose, intensity of treatment. Four studies included only people with stroke, the fifth was predominantly stroke but also brain injury. Three studies delivered intervention in the first few months after stroke, the other two recruited people with chronic dysarthria. Three studies evaluated behavioural interventions, one included acupuncture and one included transcranial magnetic stimulation. One study included dysarthria as a planned subgroup within a broader trial of impaired communication.

Our primary analysis of a persisting (long lasting i.e. 3-9 months post intervention) effect at the activity level of measurement found no evidence in favour of dysarthria intervention compared to any control (three trials, 116 participants, SMD 0.18, 95% CI -0.18 to 0.55; GRADE: low quality) with zero heterogeneity between trials (I^2 = 0%). Sensitivity analysis of the studies with low risk of bias found similarly, with a slightly wider confidence interval and slight heterogeneity (two trials, 92 participants, SMD 0.21 (-0.30 to 0.73, I^2 = 32%; GRADE: low quality). Results of the subgroup analysis for stroke was unsurprisingly similar to the primary analysis as so few non-stroke participants have been recruited to trials (three trials, 106 participants, SMD 0.16, 95% CI -0.23 to 0.54, I^2 = 0%; GRADE: low quality).

Similar results emerged from most of the secondary analyses. There was no evidence of a persisting effect at the impairment (two trials, 56 participants, SMD 0.07, 95% CI -0.91 to 1.06, I^2 = 70%; GRADE: very low quality) or participation level (two trials, 79 participants, SMD -0.11, 95% CI -0.56 to 0.33, I^2 = 0%; GRADE: low quality) but substantial heterogeneity on the former. Analyses of immediate post-intervention outcomes provided no evidence of any short -term benefit on activity (three trials, 117 participants, SMD 0.29, 95% CI -0.07 to 0.66, I^2 = 0%; GRADE: very low quality); or participation (one study, 32 participants, SMD -0.24, 95% CI -0.94 to 0.45) levels of measurement.

There was a statistically significant effect favouring intervention at the immediate, impairment level of measurement (four trials, 99 participants, SMD 0.47, 95% CI 0.02 to 0.92, p = 0.04, I^2 = 0%; GRADE: very low quality) but only one of these four trials had a low risk of bias.

Authors' conclusions

There are no definitive adequately powered randomised controlled trials of interventions for people with dysarthria. There is limited evidence that there may be an immediate beneficial effect on impairment level measures but more, higher quality research is needed to confirm this finding. So although this review evaluated five studies, the benefits and risks of intervention are still unknown and the emerging evidence justifies adequately powered clinical trials into this condition. People with dysarthria after stroke or brain injury should continue to receive rehabilitation according to clinical guidelines.

PLAIN LANGUAGE SUMMARY

Interventions for dysarthria (speech that is imprecise, weak, slow and less intelligible) after stroke or other non-progressive brain injury

Review question

Does any type of treatment help people who have difficulty speaking clearly after a stroke or other types of brain injury acquired during adulthood?

Background

Damage to the brain caused by stroke, injury or other non-progressive disease can make speech unclear and difficult for listeners to understand. This (dysarthria) is caused by the muscles of the face, tongue and throat being weak, slow and uncoordinated. It can also occur as a result of progressive neurological conditions which are not part of the remit for this review. Dysarthria can cause those affected to lack confidence when talking and become socially isolated, even if others may judge the symptoms to be mild. It is important to clarify that people with dysarthria do not have difficulties with thinking, remembering or retrieving words. Treatment is usually provided by a speech and language therapist or speech pathologist and involves advice and education plus strategies and exercises to increase clarity of speech and to cope with social interaction, but there are other types of treatment used such as acupuncture or brain stimulation. We wanted to find out if any treatments work, if the effects are long lasting (persisting) and if so which works best, when it should start, how frequent it should be and for how long.To achieve this we carried out a Cochrane review where we searched for, evaluated and summarised the quality of the existing research on this topic.

Who will be interested in this review? Adults with dysarthric speech difficulties after stroke, traumatic brain injury or other forms of brain injury. Friends and family who communicate with people with dysarthria. People who provide treatment for dysarthria such as speech and language therapists/speech pathologists. People who make referrals for treatment such as general practitioners, or who commission therapy services or write guidelines for service delivery. Researchers who wish to improve the evidence for how to support people with dysarthria.

Study characteristics

We searched databases up to May 2016 to find all studies (specifically randomised controlled trials) of any treatment focused on helping people with their dysarthric speech. Randomised controlled trials can reduce the bias that affects the value of research studies. We included five trials in the review; they were small and overall randomised only 134 people, almost all with stroke.

Key results

There are surprisingly few randomised controlled trials of dysarthria treatment. The few that exist have small numbers of participants or have not been adequately designed or reported to answer the important questions with confidence about what intervention to offer and when. Two trials investigated dysarthria treatment for people versus an attention control and three compared one treatment with another treatment, which in all three studies was usual care. There are no trials at all comparing one treatment to no treatment

Our review compared quite a large number of different measures at various time points after treatment and therefore caution is recommended when interpreting the results. There is no evidence of effectiveness on most of the measures including our main one (long lasting improvement in every day communication abilities). The one positive finding was a short-term improvement in muscle movement such as tongue and lip control. However this result is not reliable and requires confirmation in a new trial due to small numbers and concerns about the conduct and reporting of some of these trials.

Therefore, there is insufficient evidence to tell us whether any one treatment is better than any other or whether treatment is better than general support, or no treatment. There were no studies that examined timing, duration or intensity of intervention but this is a question of clinical importance and should be considered in future trials.

Quality of the evidence

The included trials varied in quality but were all small numbers. Overall we rated them as low to very low quality. More high quality and sufficiently large randomised controlled trials of dysarthria intervention should be commissioned. This research should include a range of measures which are guided by what people with dysarthria tell us are the most important to them.

SUMMARY OF FINDINGS FOR THE MAIN COMPARISON *[Explanation]*

Dysarthria intervention compared with another intervention, attention control, placebo or no intervention for people with dysarthria after stroke or other adult-acquired, non-progressive brain injury

Patient or population: adults with dysarthria following stroke or other adult-acquired, non-progressive brain injury
Settings: any
Intervention: dysarthria intervention
Comparison: another intervention, attention control, placebo or no intervention

Outcomes	Standardised mean difference (95% CI)	No of Participants (studies)	Quality of the evidence (GRADE)	Comments
Dysarthria intervention versus any control: persisting effects, activity level	0.18 [-0.18, 0.55]	116 participants 3 RCTs	⊕⊕◯◯ **low**	Very small numbers and none of the studies are adequately powered Only two of the three studies considered low risk of bias.
Dysarthria intervention versus any control: persisting effects, impairment level	0.07 [-0.91, 1.06]	56 participants 2 RCTs	⊕◯◯◯ **very low**	Very small numbers, none of the studies are adequately powered. Only one of the two studies considered low risk of bias
Dysarthria intervention versus any control: persisting effects, participation level	-0.11 [-0.56, 0.33]	79 participants 2 RCTs	⊕⊕◯◯ **low**	Both studies considered low risk of bias but very small numbers and neither study adequately powered
Dysarthria intervention versus any control for stroke sub-group: persisting effects, activity level	0.16 [-0.23, 0.54]	106 participants 3 RCTs	⊕⊕◯◯ **low**	Very small numbers and none of the studies are adequately powered Only two of the three studies considered low risk of bias.
Dysarthria intervention versus any control: immediate effects, activity level	0.29 [-0.07, 0.66]	117 participants 3 RCTs	⊕◯◯◯ **very low**	Very small participant numbers, not adequately powered. Only one of the three studies considered to be low risk of bias

Dysarthria intervention versus any control: immediate effects, impairment level	0.47 [0.02, 0.92]	99 participants 4 RCTs	⊕◯◯◯ **very low**	Very small participant numbers, not adequately powered. Only one of the four studies considered to be low risk of bias. This comparison shows a significant effect

GRADE Working Group grades of evidence
High quality: Further research is very unlikely to change our confidence in the estimate of effect.
Moderate quality: Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
Low quality: Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
Very low quality: We are very uncertain about the estimate.

BACKGROUND

Description of the condition

Dysarthria is a speech disorder affecting intelligibility due to disturbances in neuromuscular control. It affects approximately 20-30% of stroke survivors (Lawrence 2001; Warlow 2008; Lubart 2005) and 10-60% of those who survive traumatic brain injury and can occur in less common adult acquired conditions such as meningitis, encephalitis, post surgical meningioma and acoustic neuroma (Sellars 2005a). Dysarthria can be defined most comprehensively as a neurologic motor speech impairment causing the speech musculature to be slow, weak and/or imprecise. This causes poor coordination of movements involving breathing, voice production, resonance and oral articulation (Yorkston 1996). People with dysarthric speech typically sound less intelligible or slurred because of poor oral control of articulators, particularly the tongue. It can also be quiet, unempowered and lacking expressiveness because of respiratory control or impaired vocal cord function. Dysarthria includes a wide severity range with some patients being mostly unintelligible to the listener while at the milder end there may be lapses in speech accuracy, or fatigue, but speech is generally intelligible. Dysarthria has an impact that goes beyond impaired communication. It can negatively affect an individual's psychological well-being, social participation and the effects of rehabilitation, and is influenced by pre-morbid communication demands (Tilling 2001; Dickson 2008; Brady 2011). Brady 2011 found that the psychological impact can be influenced by pre-morbid levels of communication demands. An individual with a mild dysarthria but high levels of communication before their illness may experience as severe a psychological impairment as someone with a more severe dysarthria.

Description of the intervention

Behavioural interventions by a speech and language therapist (SLT) or a speech language pathologist (SLP) are the mainstay of dysarthria treatment. The primary aim is to maximise the patient's ability to communicate with others. UK treatment guidelines for dysarthria (Taylor-Goh 2005) recommend that behavioural interventions address all dimensions of the International Classification of Functioning, Disability and Health Framework; impairment, activity and participation (WHO 2007). **Impairment level** exercises to improve the strength, speed and/or function of the impaired musculature may be used. These are usually non-speech, oro-motor movements of the affected muscles or muscle groups and can also include external stimulation of the muscles such as icing, brushing in other countries acupuncture (traditional and electrical) and brain stimulation (transcranial magnetic stimulation) may be used. At the **activity and participation levels**, compensatory strategies to increase intelligibility through purposeful speech production or advice to a communication partner may be used. Alternative ways to communicate, or support speech may be used such as an alphabet chart or computers with artificial voice software. Other intervention approaches use facilitated group work, education and feedback to psychologically support

people living with dysarthria.

How the intervention might work

See Description of the intervention

Why it is important to do this review

Previous Cochrane Reviews of interventions for dysarthria (Sellars 2005) have found insufficient evidence to support or refute their effectiveness but further trials have more recently been published. The current review also broadened the scope of the search to include any possible interventions carried out by any health professional, the patient themselves or a trained individual or any other possible new approaches to treatment.

OBJECTIVES

To assess the effects of interventions to improve dysarthric speech following stroke and other non-progressive adult-acquired brain injury such as trauma, infection, tumour and surgery.

METHODS

Criteria for considering studies for this review

Types of studies

We included randomised controlled trials of interventions to improve non-progressive dysarthric speech in adults with acquired brain injuries, including comparisons with no intervention, another intervention (which may be the same intervention approach but alternative method, theory, timing, duration or frequency of intervention), attention control or placebo. For trials using a crossover randomised trial design we only included data from the first phase to avoid contamination.

Types of participants

- Individuals with a diagnosis of non-progressive dysarthria following acquired brain injury, principally stroke and traumatic brain injury.
- Adults.
- Any time since onset.

Types of interventions

We considered any type of intervention for acquired dysarthria including behavioural or psychological approaches, use of devices and medication with the exception of surgical intervention. Interventions could be carried out by any health care professional, unqualified health care staff, trained volunteer or family member/carer or the person with dysarthria.
Interventions addressed any level of the ICF (WHO 2007) including the following.

1. Impairment level - interventions specifically targeting the impairment of function, e.g. exercises to improve speed, range, strength, accuracy of speech/respiratory musculature with oromotor exercises, chewing or swallowing, brain stimulation, acupuncture (traditional or electrical).
2. Activity level - interventions to increase intelligibility by modifying existing speech (e.g. rate modification) or the use of augmentative or alternative communication devices e.g. light tech aids (non-technical materials such as an alphabet chart) and high tech aids (such as text to talk computer devices).
3. Participation level - interventions aimed at support or education for the individual with dysarthria or programmes for the individual with dysarthria and their conversational partners or conversational training as well as any psychological approaches to treatment that focus on increasing social participation.

No restrictions were placed on frequency, intensity, or duration of the interventions.

Types of outcome measures

The primary outcome measure of the review was an activity level measure at a persistent time point (3-9 months post intervention), secondary outcome measures were communication impairment measures, communication quality of life measures and generic quality of life measures at either persistent or immediate time points following intervention.

Primary outcomes

The primary outcome measure for this review was long term effectiveness of the dysarthria intervention on everyday speech (activity level, persisting effect) compared to any control (another intervention, attention control/placebo or no intervention). Attempts to objectively measure everyday speech are usually based on listener perception grading scales such as the Dysarthria Therapy Outcome Measures (dysarthria TOMs Enderby 1997) or the Communication Effectiveness Measure (CEM Mackenzie 2007). Evidence of a persistent effect of benefit was defined as around six months post intervention and for this we extracted measures taken between 3-9 months post-intervention.
When trials used more than one outcome measure at the activity level, we took the primary outcome as specified by the trial investigators. If a trial had not specified a primary outcome measure,

we checked if a measure of functional communication had been used at the specified time points.

Secondary outcomes

Secondary outcomes included exploring effects:

- at other measurement levels (e.g. impairment, participation);
- at other time points (e.g. immediate post-intervention);
- compared to specific control groups (e.g. another intervention, attention control/placebo or no intervention);
- for clinical subgroups (e.g. stroke, brain injury);
- or only the studies at low risk of bias.

Secondary outcome measures were as follows.

- Communication at impairment level (immediate and persisting): speech impairment measure e.g. Frenchay Dysarthria Assessment edition I or II (Enderby 1983), Iowa Oral Performance Instrument (IOPI, IOPI 2005), measures of intelligibility (e.g. Assessment of intelligibility of Dysarthric Speech, Yorkston 1984), acoustic and perceptual measures of voice and speech (e.g. vocal profile analysis, pitch, loudness, air flow, sound spectography).
- Communication at activity level (immediate): activity measure (e.g. Dysarthria Therapy Outcome Measure, Enderby 1997), listener acceptability measures.
- Communication related quality of life (immediate and persisting participation level): patient perception of impact e.g. Dysarthria Impact Profile (Walshe 2009), Communication Outcomes after Stroke Scale Long 2008.
- Generic quality of life measures: Mood scales (e.g. Hospital Anxiety and Depression Scale Zigmond 1983); subjective health scales (e.g. Euroqol, SF-36 Herdman 2011).

Search methods for identification of studies

See the 'Specialized register' section in the Cochrane Stroke Group module. There were no language restrictions and we sought translations for non-English language studies.

Electronic searches

We searched the Cochrane Stroke Group Trials Register (last searched by the Managing Editor in May 2016). We searched the Cochrane Central Register of Controlled Trials (CENTRAL The Cochrane Library 2016, Issue 4 of 12; Appendix 1), MEDLINE (1946 to May 2016; Appendix 2), EMBASE (1974 to May 2016; Appendix 3), CINAHL (1937 to May 2016; Appendix 4) using comprehensive search strategies, PsycINFO (searched 1800 - September 2016; Appendix 5) and LLBA (1976 to November 2016; Appendix 6).

We searched major trials registers for ongoing trials including the World Health Organisation International Clinical Trials Registry Platform (http://www.who.int/ictrp/search/en/), the ISRCTN registry (http://www.isrctn.com/), ClinicalTrials.gov (http://www.clinicaltrials.gov/) and the Stroke Trials Registry (www.strokecenter.org/trials/).

Searching other resources

In an effort to identify further published, unpublished and ongoing trials we hand-searched the reference lists of relevant articles and contacted academic institutions and other researchers.

Data collection and analysis

Selection of studies

Our selection criteria were as follows.

- Research participants with dysarthria following stroke or other adult-acquired, non-progressive brain injury.
- Interventions designed to reduce the dysarthria or its impact on living with dysarthria.
- Randomised controlled trials.

One author, CM, excluded any obviously irrelevant reports from the titles and abstracts retrieved in the search. The review team (CM, AB, PC) independently examined the remaining abstracts and then full texts to determine eligibility and exclude irrelevant reports. Discussion was sufficient to resolve any disagreements. No author examined their own study. Conference proceedings and dissertations that were difficult to retrieve were pursued using email contacts, university alumni societies and conference committees. We arranged for relevant reports to be translated where required. We contacted authors of the studies, where possible, for further clarification of details to support discussions around eligibility. All authors agreed the final decision on the included papers and proceeded to data collection. The studies judged ineligible for this review, are listed, with the reasons for exclusion in the table Characteristics of excluded studies.

Data extraction and management

Authors from the review team (CM, AB, PC) independently carried out data extraction from trial reports in pairs (avoiding authors' own trials), extracting the following data;

- Methods: study design, study duration, sequence generation, allocation sequence concealment, blinding
- Participants: total number, attrition, setting, diagnostic criteria, age, gender, country of research
- Interventions: total number of intervention groups, specific intervention and details

- Outcomes: Outcomes and time points, outcome definition and measurement
- Results: Number of participants allocated to each intervention, sample size, missing participants, summary data.

We contacted authors of the selected trials, where possible, for further information where risk of bias was unclear or data were missing. The independent data extraction between the pairs of reviewers was reconciled and any disagreements would have been resolved by discussion or with reference to an independent arbitrator (ST) but this was not required.

Assessment of risk of bias in included studies

The review team (CM, AB, PC) independently carried out the assessment of risk of bias and methodological quality within the pairs assigned for data extraction. The authors used the Cochrane Collaboration's Risk of bias tool (Higgins 2011). The studies were examined for the following quality criteria: random sequence generation, allocation concealment, blinding of outcome assessors, incomplete outcome data and selective reporting.

For random sequence generation (selection bias), trials were considered to be low risk if the random component was clearly described and a high risk of bias would involve randomisation influenced by the availability of the intervention or an unclear risk would indicate insufficient information to decide. For allocation concealment (selection bias), trials were considered adequately concealed if the process made clear that participants and investigators could not possibly predict allocation. A study would be considered high risk if there was a possibility that allocation could be predicted (e.g. open random allocation schedule, open computer systems potentially accessible to the investigator) or where concealment was unclear and the author was unable to provide sufficient information or did not respond.

It is accepted that the participants and the therapists delivering the intervention could not be blinded to the intervention. Thus, we considered blinding in terms of outcome assessment (performance bias and detection bias) and a low risk of bias was considered present if the outcome assessor was clearly blinded to the intervention. A high risk of bias was considered if this was not the case; the blinding could be broken or if it was unclear and there was insufficient information provided.

Incomplete outcome data (attrition bias) was considered low risk if there were:

- no missing outcome data
- missing outcome data that were unlikely to be related to true outcome
- missing outcome data that were balanced in numbers across intervention groups
- similar reasons for missing data across groups
- missing data that had been imputed using appropriate methods that did not affect outcome and were reported as such.

Studies were considered to have a high risk of bias if they did not address:

- incomplete outcome data adequately
- missing outcome data likely to be related to true outcome
- imbalance of numbers or reasons for missing data across the intervention groups
- effect size among missing outcomes to induce clinically relevant bias
- an intention to treat analysis done with substantial differences of the intervention received
- insufficient information to allow us to assess this

Selective reporting (reporting bias) was considered within studies included in the review. We considered whether studies had reported all outcome data compared to their planned protocols (published or unpublished) where possible. Where this was not possible authors were asked for additional information on planned outcome reporting prior to the study. Authors who did not respond to this were considered an unclear risk.

Measures of treatment effect

We treated the measures of functional speech as a continuous measure. We abstracted, calculated or requested means and standard deviations. We calculated standardised mean differences (SMDs) and confidence intervals (CIs), using a random effects model for the primary outcome and for any secondary outcomes measures included.

Unit of analysis issues

For continuous data we requested or calculated the mean and standard deviation (SD) data. We analysed outcomes as the standard mean difference (SMD) and 95% confidence interval (CI). We used inverse variants and random effects models. We entered data so that a higher score represented a favourable outcome.

We used the Cochrane Review Manager 5.3 software for all analyses.

Dealing with missing data

We requested missing data from the study authors. We have noted in the characteristics of included studies table whether these were provided Characteristics of included studies.

Assessment of heterogeneity

We assessed heterogeneity between trials with the selected comparisons and outcomes comparing measures, time points, trial design and clinical sub-groups. Statistical heterogeneity was determined based on the statistic with Chi^2 distribution. We quantified heterogeneity using the I^2 statistic which describes the proportion of

total variance across trials. We considered heterogeneity of 40%+ as considerable and 70%+ as substantial Deeks 2008.

Assessment of reporting biases

We planned to explore reporting bias if ten or more trials are selected for the review as outlined in The *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Data synthesis

The primary analysis pooled all trials in the meta-analysis, using a random-effects model, including the dysarthria intervention versus any control (another intervention, attention control, placebo or no intervention). We considered the data of the primary outcome measures as well as the secondary outcome measures at various time points (immediate and persistent) and various levels of functioning.

GRADE and 'Summary of findings' table

We created a Summary of findings for the main comparison for the main comparison and included the following outcomes: 1) Dysarthria intervention versus any control: persisting effects, activity level; 2) Dysarthria intervention versus any control: persisting effects, impairment level; 3) Dysarthria intervention versus any control: persisting effects, participation level; 4) Dysarthria intervention versus any control for stroke sub-group: persisting effects, activity level; 5) Dysarthria intervention versus any control: immediate effects, activity level; 6) Dysarthria intervention versus any control: immediate effects, impairment level. We used the five GRADE considerations (study limitations, consistency of effect, imprecision, indirectness and publication bias) to assess the quality of the body of evidence as it relates to the included studies (Atkins 2004). We used methods and recommendations described in Section 8.5 and Chapter 12 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011) using GRADEproGDT software (GRADEproGDT 2015). We have justified all decisions to down- or up-grade the quality of studies using footnotes, and we have made comments to aid the reader's understanding of the review where necessary.

Subgroup analysis and investigation of heterogeneity

We carried out subgroup analysis to explore the effect of comparison with all controls (another intervention, attention control, placebo or no intervention). We carried out clinical subgroup analysis of stroke or brain injury and a subgroup sensitivity analysis where studies had low risk of bias.

Sensitivity analysis

We carried out sensitivity analysis to explore methodological heterogeneity including studies with adequate allocation concealment and adequate blinding; these were the studies considered to be at low risk of bias.

RESULTS

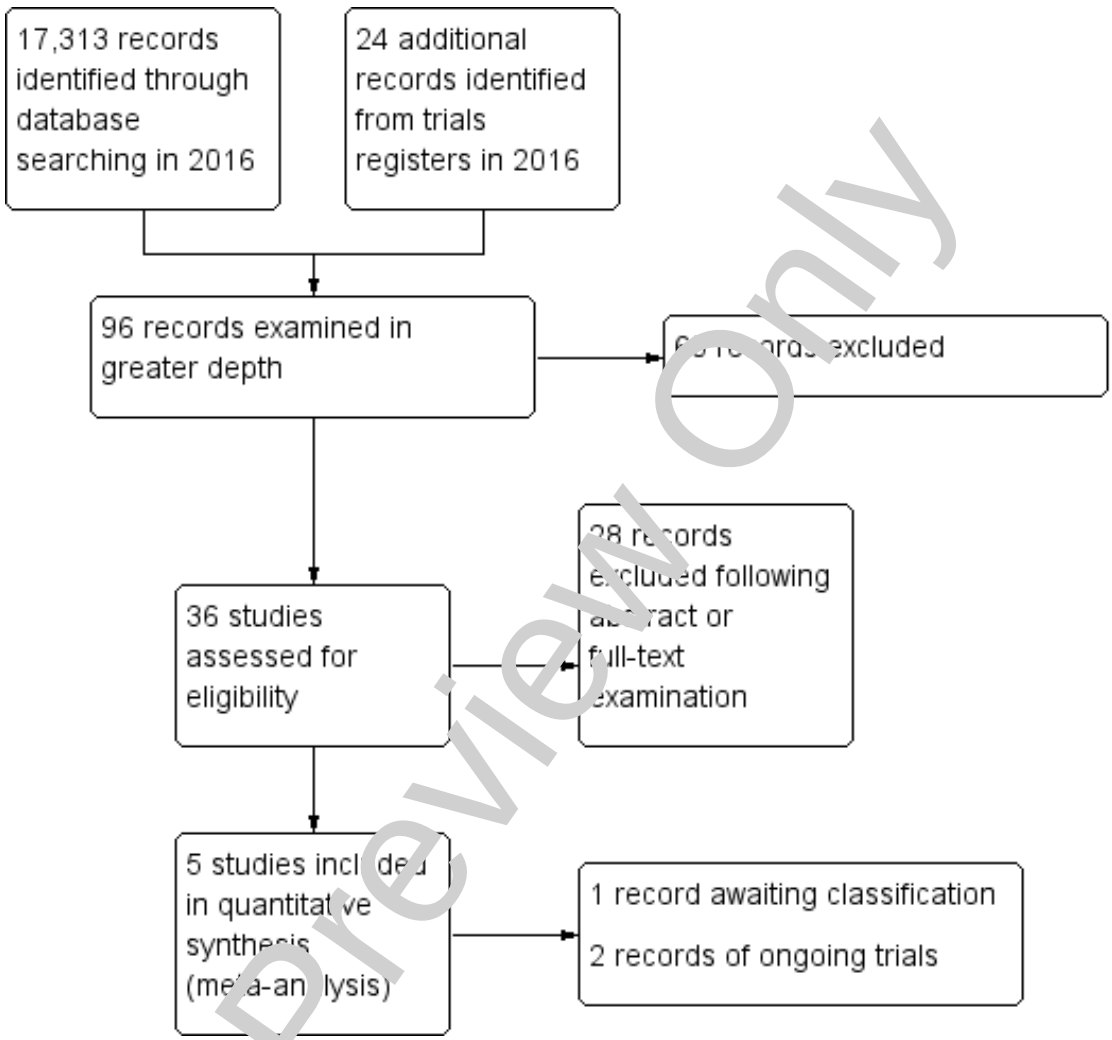
Description of studies

See Characteristics of included studies; Characteristics of excluded studies; Characteristics of ongoing studies; Characteristics of studies awaiting classification

Results of the search

Searches identified 17,313 citations and the screening process is shown in the PRISMA flow diagram (Figure 1). Five papers met the inclusion criteria for the review: Wenke 2010, Xu 2010, Bowen 2012, Mackenzie 2014, Kwon 2015 and are described in the Characteristics of included studies. Following our search we identified two ongoing studies ReaDySpeech and Peng 2015 described in Characteristics of ongoing studies. ReaDySpeech is a feasibility study but may be eligible for inclusion in the review at a later date. Peng 2015 is an abstract only and potentially suitable for inclusion in the review but we have insufficient detail in the abstract to make this decision and we await a response from the authors about further information or the publication of the study in full. One study retrieved, You 2010, has an English abstract which does not have enough information to make a decision regarding inclusion and is therefore in Characteristics of studies awaiting classification. We are awaiting contact from the lead author for further clarification before a decision can be made about inclusion in the review and whether translation from Korean is warranted.

Figure 1. Diagram of electronic search and study selection.



Included studies

The selected trials randomised 234 participants in total, ranging from 25 (Kwon 2015) to 66 (Bowen 2012). The selected five trials are detailed in the Characteristics of included studies. We have included the comparison data below and further information on participant characteristics in each study are in Table 1. All studies were randomised controlled trials and the included trials contribute to more than one comparison. We present data that compares one dysarthria intervention with another dysarthria intervention and a dysarthria intervention with an attention control. We had no studies comparing dysarthria intervention with nothing or the same dysarthria interventions with variations in timing, duration or frequency of delivery. Further information on the intervention characteristics are in Table 2 and the main comparisons are found in the Summary of findings for the main comparison.

Participant characteristics

All five trials recruited men and women with the proportion of men ranging from 56% (Bowen 2012) to 85% (Kwon 2015). The average age ranged from 49 years (Wenke 2010) to 70 years (Bowen 2012). Four studies included only people with stroke (Xu 2010, Bowen 2012; Mackenzie 2014; Kwon 2015) and one study included people with stroke and a small number with traumatic brain injury (Wenke 2010). Two studies tested an early intervention, provided in the first 4 months (Bowen 2012) and 2 months

post stroke (Kwon 2015). Two studies involved participants in the chronic stage of recovery (Wenke 2010; Mackenzie 2014). The other study included patients between 1 to 12 months post stroke (Xu 2010). Participants were recruited from hospital (Xu 2010; Bowen 2012), the community (Mackenzie 2014), or the source of recruitment location was not specified (Wenke 2010) or not clear (Kwon 2015). Dysarthria severity was reported in Wenke 2010, Bowen 2012 and Mackenzie 2014 with this having been assessed and reported as part of the baseline characteristics. Patients with severe dysarthria were excluded in Xu 2010 and severity was not reported in Kwon 2015. A co-occurring communication impairment or cognitive problem was excluded in Xu 2010 and Kwon 2015. A co-occurring aphasia was described in Bowen 2012 and Mackenzie 2014 but not mentioned in Wenke 2010, however Wenke 2010 identified co-existing cognitive impairment. The Bowen 2012 study recruited people with communication difficulties post stroke including aphasia, dysarthria or both. People with dysarthria were a planned subgroup within that study and we extracted all the dysarthria data from the main trial data.

Intervention and control interventions

No study compared dysarthria intervention with nothing. Two trials compared an intervention with an attention control, Bowen 2012 and Kwon 2015. Bowen 2012 investigated an intervention (enhanced best practice speech and language therapy delivered by speech and language therapists supported by assistants) compared to an attention control (employed individuals offering an equivalent amount of time and social contact but no therapy or therapist input). Kwon 2015 investigated the intervention of repetitive transcranial magnetic stimulation (rTMS) versus an attention control of sham rTMS, with both groups receiving the same speech therapy intervention.

Three trials, Wenke 2010, Xu 2010 and Mackenzie 2014 compared one dysarthria intervention A with another dysarthria intervention B, and the B intervention in all three studies was usual dysarthria care. There were no comparisons of one intervention versus the same intervention with variations in timing, intensity or duration of treatment. The dysarthria intervention A for Wenke 2010 was the Lee Silverman Voice Treatment (LSVT), an approach that focusses on increased volume of speech with usual care, for Xu 2010 it was the inclusion of acupuncture with usual care and for Mackenzie 2014 it was the inclusion of oro-motor exercises. The usual care reported by Wenke 2010, Xu 2010 and Mackenzie 2014 was described as behavioural strategies that address impairment and activity levels of functioning. Wenke 2010 and Mackenzie 2014 report this usual care as based on existing literature and best practice guidelines with Wenke 2010 also including consensus agreement. No detail is given by Xu 2010 as to the content of usual care. The template for intervention description and replication checklist (TiDier) was referred to when extracting the information on the interventions for each study Hoffmann 2014.

Intervention compared with attention control

The included trials involved 86 randomised participants (Bowen 2012 and Kwon 2015) The dysarthria intervention in the Bowen 2012 study was enhanced, flexible, best practice behavioural speech therapy, and in the Kwon 2015 study the intervention was repetitive transcranial magnetic stimulation (rTMS). The enhanced, best practice intervention in Bowen 2012 was described in sufficient detail for replication from the manual provided and was agreed by consensus of speech and language therapists to address impairment, activity and participation levels of functioning. The Kwon 2015 study describes the rTMS intervention, the equipment and how they established and calculated motor evoked potentials for each patient. The delivery of the intervention in the Bowen 2012 study was to be led by an experienced speech and language therapist, the Kwon 2015 study intervention was carried out by a 'physiatrist'. The attention control in the Bowen 2012 study was structured social contact, carried out by employed, part-time, visitors, with five out of the nine having a high level of educational attainment. In the Kwon 2015 study the attention control was sham rTMS, carried out by the same 'physiatrist' and in the same way as the actual rTMS but the coil was held perpendicular to the skull rather than tangential to it. The population for both studies was stroke, both interventions and attention control were delivered at the same time, early post stroke, within the first two months (Kwon 2015) and within the first four months (Bowen 2012). The duration of the rTMS intervention was for five days a week for two weeks (Kwon 2015) and the enhanced speech therapy was for a maximum of 16 weeks (Bowen 2012) with duration and frequency as clinically indicated up to a maximum of three times a week. The Bowen 2012 study mentions homework which was given, as appropriate, to those in the intervention arm of the study but not the attention control arm. In the intervention manual (unpublished), made available by the Bowen 2012 study authors, there is a sheet to encourage documentation of homework by the participants but there is no further description of whether this was carried out or completed. Participants in the intervention arm do discuss homework and the impact of this during the interviews as part of the qualitative aspect of this study. The Kwon 2015 study describes that both groups had the same speech therapy intervention carried out for 30 minutes, five days a week for the two weeks of rTMS treatment but no detail of what the speech therapy intervention was, although it was carried out by a skilled speech therapist. There is no mention of homework in the Kwon 2015 study. Participants in the Kwon 2015 study were not aware of the intervention type they were randomised to either the active rTMS or the attention control/sham rTMS. The outcome measure for Kwon 2015 was a blinded assessment of impairment level immediately post intervention.Participants in the Bowen 2012 study were aware of the intervention type they were

randomised to and the primary outcome was a blinded assessment of activity level functioning at six months post-entry to the study.

Intervention A compared with intervention B

Three trials used this design comparing one intervention with another intervention, which for all three of these studies was 'usual' care versus an alternative intervention. There were no trials that compared one intervention with the same intervention but with variations in timing, duration or intensity of delivery. We included 3 trials involving 117 randomised participants (Wenke 2010, Xu 2010 and Mackenzie 2014). The intervention A for Wenke 2010 was the 'Lee Silverman Voice Treatment' (LSVT) an intervention that works on one main aim which is to increase vocal loudness, for Xu 2010 it was the inclusion of acupuncture and for Mackenzie 2014 it was the substitution of ten minutes non-speech oro-motor exercises (tongue and lip movements) instead of ten minutes word and sentence practice. So all three studies had the comparison, intervention B, of usual care. This was described in Wenke 2010 and Mackenzie 2014 as behavioural therapy, addressing impairment and activity levels of functioning with both studies detailing sufficient information for replication detailing how and when it was delivered. Xu 2010, did not describe intervention B in sufficient detail, with no information around the content of the therapy, what level of impairment or how it was delivered. The intervention A was delivered by the same speech pathologist trained in LSVT in Wenke 2010, the traditional Chinese medical specialists carried out the acupuncture in Xu 2010 and the same experienced speech and language therapist in Mackenzie 2014. The intervention B, was delivered by an experienced speech pathologist in Wenke 2010, the same hearing and speech specialist delivered the usual care to both arms of the trial in Xu 2010 and the same experienced speech and language therapist delivered both intervention A and B in Mackenzie 2014. Timing of intervention was for people in the chronic phase of recovery following stroke or brain injury, more than six months in Wenke 2010, and more than three months Mackenzie 2014, but in Xu 2010 this ranged from acute to chronic between 1-12 months post stroke. The duration of treatment ranged from four weeks (Wenke 2010) up to eight weeks (Mackenzie 2014) and nine weeks (Xu 2010). The frequency of intervention A and B was the same for Wenke 2010, at one hour a day, four days a week, and the same for Mackenzie 2014 at 45 minutes once a week, but Xu 2010 differed slightly with both arms having speech therapy for 30 minutes, five times a week but intervention A was delivered for four weeks, with a week long break followed by four weeks of intervention A. Independent practice of home work was described in Wenke 2010 and Mackenzie 2014 but was not used in the Xu 2010 study. In Wenke 2010, this independent, daily homework was suggested in between sessions for the intervention B group only but whether this was carried out and recorded was not described. In Mackenzie 2014 the participants in both intervention A and B were encouraged to carry out independent practice of their allocated intervention of around 30 minutes, five days a week during the seven between session practice weeks so a total of 1050 minutes, and this was documented by participants in a diary and the results reported and analysed. All of the participants in the three studies knew what intervention they were randomised to, none had a primary outcome measure. All three studies carried out an activity level measure, with this being considered to show persistent change for Wenke 2010 at six months post treatment and Mackenzie 2014 at 2 months post intervention in a chronic population but was only carried out immediately post intervention in Xu 2010.

Outcomes

All five studies used different outcome measures, and at various time points. The primary outcome for this review was to examine the persisting effect of intervention at the activity level of functioning. Four of the studies carried out activity level measures; Wenke 2010 and Xu 2010 used a measure of perceived intelligibility by a speech and language therapist, Bowen 2012 used the dysarthria Therapy Outcome Measures (TOMs), (Enderby 1997). Mackenzie 2014 used the communicative effectiveness measure (CEM), (Mackenzie 2007). The only study that specified the primary outcome measure was Bowen 2012 . The measures of activity level from these four studies were the dysarthria TOMS (Bowen 2012), the CEM (Mackenzie 2014), perceptual ratings of speech intelligibility (Wenke 2010) and intelligibility improvement ratings Xu 2010 but these could not all be analysed due to these measures being carried out at various time points. For our analyses of persisting outcome, we took data from measures carried out at 3-9 months post intervention, this included: Wenke 2010 (6 months post treatment) and Bowen 2012 (measured at 6 months post randomisation). Mackenzie 2014 carried out their final outcome measure at 2 months (8 weeks) post intervention and the review authors discussed at some length whether these data should be included as this was a chronic population with proximity to the proposed minimum time point of 3 months (12 weeks). This discussion indicated that the proposed time criteria (3-9 months) in the protocol was too tight and we agreed to relax the timings to include the study data as a persisting effect, it is important to note this is a change from the protocol Differences between protocol and review. The latest time point for the primary outcome measure taken by Xu 2010 was immediately post intervention which did not meet our requirement of 3-9 months post intervention to examine persistent change. Kwon 2015 did not carry out a measure of activity level of functioning.

The secondary outcomes were other measures at various time points. This meant we examined the data from the activity level measures at immediate time point post-intervention and this had been carried out by Wenke 2010, Xu 2010 and Mackenzie 2014. For this review we considered 'immediate' measure to have been carried out at the end of the treatment period or the time pe-

riod nearest to the end of treatment. Communication impairment measures were used in four of the studies: articulatory precision in Wenke 2010, maximum phonation time in Xu 2010 and lip and tongue movements from the Frenchay dysarthria assessment (FDA-2) in Mackenzie 2014 and an articulation test in Kwon 2015. These impairment measures were carried out to show persistent effect between the 3-9 month time points by Wenke 2010 and Mackenzie 2014 but not Xu 2010 or Kwon 2015. These measures were carried out immediately post-intervention by all four studies (Wenke 2010; Xu 2010; Mackenzie 2014; Kwon 2015). Measures at the participation level were used by Bowen 2012 who used the Communication Outcomes after Stroke Scale (COAST) (Long 2008) and Mackenzie 2014 who used the Communicative Effectiveness Survey (CES Donovan 2007). These two studies both carried out this participation level measure as a persistent measure of change between 3-9 months but only Mackenzie 2014 carried this out immediately post treatment.

Excluded studies

See: Characteristics of excluded studies

Twenty-eight studies were excluded primarily because they did not include a randomised controlled trial (Nagasawa 1970; Jones 1972; Ince 1973; Markov 1973; Katic 1973; Huffman 1978; Fukusako 1989; Garcia 1998; Robertson 2001; Hustad 2003; Palmer 2004; Varma 2004; Rosenbek 2006; Palmer 2007; Fitzgerald-DeJean 2008; Li 2013; Sakharov 2013; Huh 2014; Togher 2014). Other reasons were that participants did not have dysarthria (Braverman 1999; Sze 2002; Togher 2004; Behn 2011; Behn 2012) or mixed aetiologies including progressive and congenital conditions (Cohen 1993; Main 1998; Kelly 2000) or a surgical intervention (Q[illegible]lan 2002).

Risk of bias in included studies

Figure 2 and Figure 3 summarise the risk of bias across the five included studies and further comments are described below. Please see the 'Risk of bias' table in the Characteristics of included studies for justification of specific judgements for each trial. Three review authors independently reviewed the included studies for methodological quality (avoiding their own studies) and any discrepancies were then discussed. We intended to carry out sensitivity analysis according to studies at low risk of bias for the different headings. Two studies (Bowen 2012; Mackenzie 2014) were considered low risk of bias across all domains and included in the sensitivity analysis. All five included studies detailed their inclusion and exclusion criteria.

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

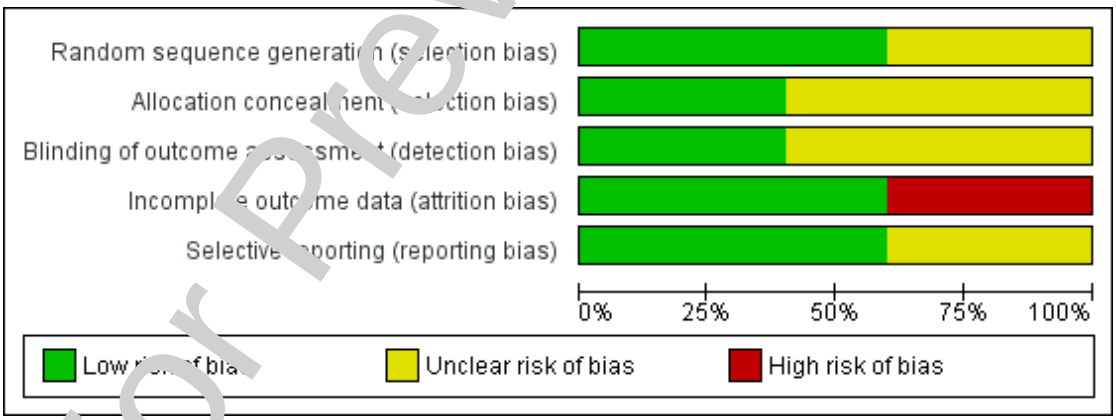
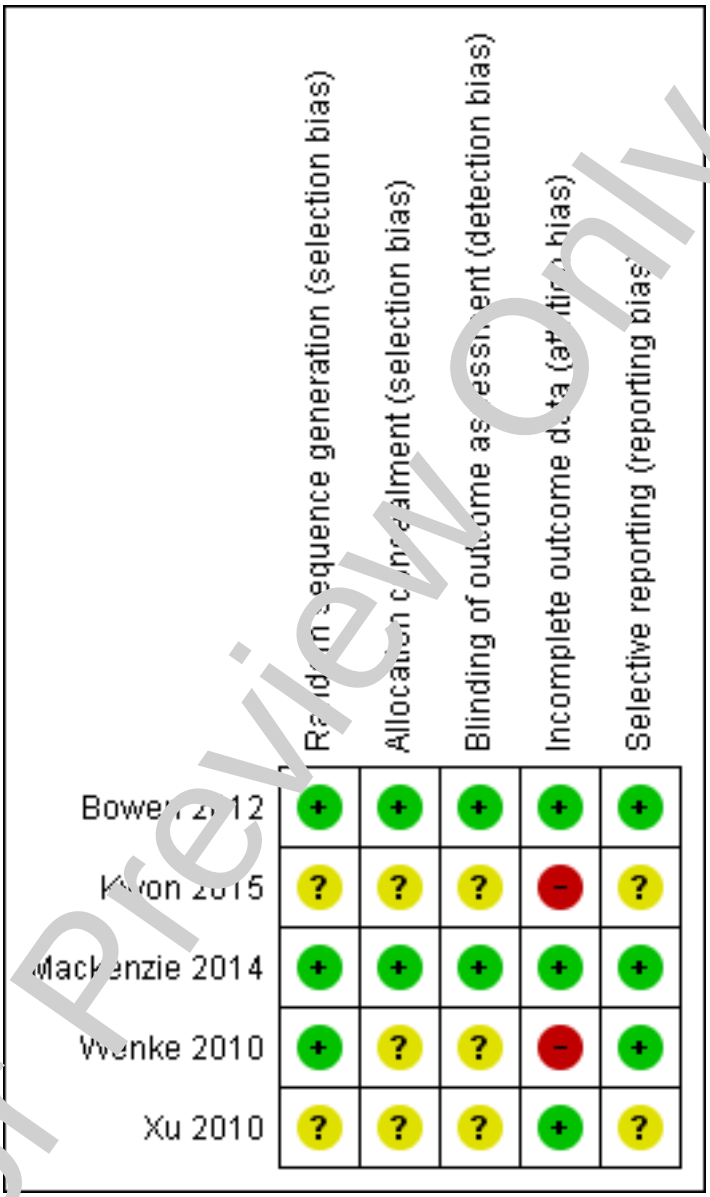


Figure 3. Risk of bias summary: review authors' judgements about each risk of bias item for each included study.



Allocation

We assessed two of the included RCTs as having low risk of bias with both random sequence generation and allocation concealment (Bowen 2012; Mackenzie 2014). One of the studies while demonstrating random sequence generation provided insufficient details to determine adequacy of allocation concealment (Wenke 2010). Two studies provided insufficient details around random sequence generation and allocation concealment and were considered to have unclear risk of bias without further clarification (Xu 2010; Kwon 2015). All of the included studies demonstrated adequate matching between randomised groups at baseline with no obvious concerns around risk in this area.

Blinding

Blinded outcome assessment on all measures was clearly described by Bowen 2012 and Mackenzie 2014. It is not clear in the trials by Wenke 2010, Xu 2010 or Kwon 2015 whether those involved in the outcome assessments were blind to the intervention. Although there is an implication that those carrying out the outcome measures were not involved in the study, the wording is not clear enough for this to be low risk without further information and evidence that the blinding process was not easy to break.

Incomplete outcome data

Not all of the studies described completion of intervention, those that did Bowen 2012, Mackenzie 2014 and Kwon 2015 reported a total of 14 (from 112 randomised) withdrawals from intervention with no differences between the intervention groups. All five studies reported on loss to follow up assessments with 33 (234 randomised) from the total number of being reported as missing some or all of these, this was clearly described in Xu 2010; Bowen 2012; Mackenzie 2014 and Kwon 2015. The study by Xu 2010 was considered to be low risk of bias for attrition as there was no attrition in this study from recruitment to follow up. Bowen 2012 was low risk as incomplete data and how these were treated in terms of data analysis were explained in detail. The missing data in Mackenzie 2014 was potentially an unclear risk of bias but on further discussion with the authors they satisfied the reviewers that their previous analysis using imputed results and multiple imputation had made no difference to the findings and this study was rated as low risk of bias. The Wenke 2010 study reported that they treated missing data in a standard statistical way, however the implications were not fully addressed and considered to be high risk without further information. The Kwon 2015 study raised significant concerns regarding incomplete outcome data, which were also rated as high risk. In the Kwon 2015 study five participants were randomised to both treatment arms but then three withdrew from the active treatment arm and two from the sham treatment. Their data were then withdrawn completely from the study with no intention to treat analysis carried out or discussion around the implications of these withdrawn data on their conclusions. Adherence to intervention and dropout rate by included study is described in Table 2

Selective reporting

Wenke 2010, Bowen 2012 and Mackenzie 2014 reported their studies in full with specified outcome measures at specified time points. Furthermore Bowen 2012 published the planned protocol and analyses. This was harder to ascertain for, Xu 2010 and Kwon 2015 which are considered an unclear risk until this can be confirmed with further discussion and clarification from the authors.

Effects of interventions

See **Summary of findings for the main comparison**
Summary of findings for the main comparison

We included five studies in this review involving 234 randomised participants. These five studies involve three main comparisons with dysarthria intervention compared to any control, dysarthria intervention versus attention control/placebo or no intervention and dysarthria intervention A versus dysarthria intervention B (whether this is two different interventions or the same interventions with varying timing, duration and frequency of delivery). These comparisons were then analysed according to our primary outcome of persisting effects of communication at activity level (3 RCTs), 116 participants. These comparisons were then analysed for measurement of impairment and participation at immediate and persistent time points. The data was also considered for one subgroup of stroke as there was insufficient data for any other clinical subgroups.

We calculated a standardised mean difference (SMD) and 95% confidence interval (CI) as different measures were used of the same underlying construct, and used a random-effects model. The results are described below for the comparisons for each outcome.

1. Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: persisting effects.
2. Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: immediate effects.
3. Dysarthria intervention A versus dysarthria intervention B: persisting and immediate effects.

Comparison 1: Dysarthria intervention versus any control: persisting effects (3-9 months post intervention), activity level

Three RCTs (116 participants) found no evidence of an effect for persisting effects at communication activity level for any control (Wenke 2010; Bowen 2012; Mackenzie 2014). SMD 0.18 (95% CI -0.18 to 0.55) Heterogeneity: Tau² = 0.00; Chi² = 1.47, df = 2 (P = 0.48); I² = 0%; GRADE: low quality. The findings were very similar to each other with narrow confidence intervals but very small numbers and none of the studies were adequately powered to find an effect Analysis 1.1. Two of the three studies were considered low risk of bias.

Stroke sub-group for comparison 1 included 3 studies, 106 participants (Wenke 2010; Bowen 2012; Mackenzie 2014) and shows no evidence of an effect with SMD 0.16 (95% CI -0.23 to 0.54) and low heterogeneity: Chi² = 1.61, df = 2 (P = 0.45); I² = 0%; GRADE: low quality Analysis 1.6.

Seconday outcomes (1.2-1.5) of dysarthria intervention versus any control: persisting effects (3-9 months), impairment or participation level

The two included RCTs (56 participants), found no evidence of a persisting effect on impairment level measures in favour of any treatment: SMD 0.07 (95% CI -0.91 to 1.06). Heterogeneity: Tau² = 0.35; Chi² = 3.32, df = 1 (P = 0.07); I² = 70%; GRADE: very low quality (Wenke 2010; Mackenzie 2014). There was substantial heterogeneity between the trials Analysis 1.2. Small numbers, neither study adequately powered and one study considered low risk of bias.

These two RCTs (79 participants) found no evidence of an effect of a persisting effect at the participation level (Bowen 2012; Mackenzie 2014). The SMD is -0.11 (95% CI -0.50 to 0.33) and Heterogeneity: Tau² = 0.00; Chi² = 0.16, df = 1 (P = 0.69); I² = 0%; GRADE: low quality Analysis 1.3. These two studies have small numbers, they are not adequately powered and only one is low risk of bias.

Sensitivity analysis of dysarthria intervention versus any control (persisting effects, activity level) includes two studies (Bowen 2012; Mackenzie 2014) with adequate allocation concealment/ adequate blinding. The data from the sensitivity analysis of these two studies with 92 participants shows no effect and slight heterogeneity (SMD is 0.21 (95% CI -0.30 to 0.73), Heterogeneity: Tau² = 0.05; Chi² = 1.47, df = 1 (P = 0.23); I² = 32%; GRADE: low quality) Analysis 1.4 .

Only one of the studies had a comparison of dysarthria intervention versus attention control with a measure of persisting effects at the activity level. This one study with 60 participants, SMD 0.00 (95% CI -0.51 to 0.51) indicates no evidence of an effect when comparing the intervention to an attention control (Bowen 2012) Analysis 1.5.

The following outcomes (2.1 to 2.3) include dysarthria intervention compared to another intervention, attention control, placebo or no intervention: immediate effects at activity, impairment and participation level

Three included studies (Wenke 2010; Xu 2010; Mackenzie 2014) had measures of activity level immediately post intervention, with 117 participants but found no evidence of an effect SMD 0.29 (95% CI -0.07 to 0.66). The heterogeneity between the studies was low but very small numbers (Heterogeneity: Chi² = 0.64, df = 2 (P = 0.73); I² = 0%, GRADE: low quality Analysis 2.1.

Four studies measured impairment level immediately post intervention (Wenke 2010, Xu 2010, Mackenzie 2014, Kwon 2015). These studies had a total of 9[illegible] participants, so small numbers but there was a statistically significant effect favouring intervention (p = 0.04), SMD of 0.[illegible]7 (0.02, 0.92) with low heterogeneity (Heterogeneity: Chi² = 0.[illegible]3, df = 2 (P = 0.69); I² = 0%). Only one study was low risk of bias, GRADE: very low quality Analysis 2.2.

One study [illegible]ie 2014, measured participation level immediately post intervention. This single study had 32 participants, a SMD of -0.24 (95% CI -0.94 to 0.45) indicating no effect of intervention Analysis 2.3.

The following outcomes (3.1 to 3.2) include dysarthria intervention A versus dysarthria intervention B: persisting and immediate effects at activity, impairment and participation level.

Due to the small number of studies in this review there are only two comparisons in this section that have not already been carried out in the earlier analysis. It may be possible to populate this section more fully in the future as more trials are carried out.

One analysis, Analysis 3.1 includes two studies of 56 participants (Wenke 2010; Mackenzie 2014) comparing intervention A versus B that with a measure of persisting effects at the activity level with a SMD of 0.38 (95% CI -0.15 to 0.91) indicating no effect of intervention. These studies have low heterogeneity (Heterogeneity: Tau² = 0.00; Chi² = 0.43, df = 1 (P = 0.51); I² = 0%; GRADE: very low quality).

The second analysis of intervention A versus intervention B that has a measure of persisting effect at the participation level, is Mackenzie 2014 . This study has 32 participants SMD -0.22 (95% CI -0.92 to 0.47) and indicates no effect of intervention Analysis 3.2.

We would also have carried out analysis on intervention A versus intervention B, persisting effects at the impairment level but this has been carried out in Analysis 1.2.

We would have looked at intervention A versus intervention B, immediate effects; activity level (shown in Analysis 2.1), impairment level (shown in Analysis 2.2), participation level (shown in Analysis 2.3) but these have already been carried out in the earlier comparisons.

DISCUSSION

This review to examine the effectiveness of dysarthria intervention for people with speech problems due to stroke and other adult-acquired, non-progressive brain injury has been amended and updated to reflect a more global reach, and to consider new evidence. We considered whether dysarthria intervention is effective when compared to any control, whether dysarthria intervention is more effective than an attention control and whether one type of dysarthria intervention is more effective than another or whether one type of dysarthria intervention is more effective than the same intervention when delivered in a different way. We found five studies suitable for inclusion and presented the data from these 234 randomised participants.

Summary of main results

See: Summary of findings for the main comparison. This review includes information from five studies, 234 randomised participants to analyse comparison of dysarthria intervention versus any control, dysarthria intervention versus attention control/placebo or no intervention and dysarthria intervention A versus dysarthria intervention B. Meta-analyses demonstrated no evidence of a statistically significant persisting effect of dysarthria intervention compared with any control when communication was measured at either the activity (three studies, 116 participants), impairment (two studies, 56 participants), or participation level (two studies, 79 participants). This lack of effect did not change in sensitivity analyses of only the studies with low risk of bias (two studies, 92 participants) or when analysis was restricted to those with an attention control/placebo (one study, 60 participants) or to the subgroup of those with an underlying condition of stroke (three trials, 106 participants). Similarly, there is no evidence for the immediate effect of dysarthria intervention at the activity (three studies, 117 participants) or participation level (one study, 32 participants). There is a significant immediate post-intervention effect at the impairment level (four trials, 99 participants) in favour of dysarthria intervention compared with any control. Clinically this means there may be some improvements for example to tongue and lip movement, precision of articulation or breath support immediately after treatment but there is no evidence that these last long-term and the very small numbers and very low quality of the evidence make this an uncertain estimate.

Key findings from this review

- There were five small RCTs that could be included in this review of dysarthria intervention after stroke or brain injury
- One of the studies had mixed aetiology of stroke and brain injury while the remainder were all stroke specific
- All five studies used different outcome measures and time points for measurement
- There was low risk of bias in two of the studies
- Despite one positive finding there is insufficient evidence to draw firm conclusions due to quality of the evidence
- The evidence was graded as low or very low

Overall completeness and applicability of evidence

The included studies are all relevant to the review question in that they are all RCTs of dysarthria intervention for stroke and brain injury. We found no RCTs for other types of non-progressive brain injury that may cause dysarthria. There was variable amounts of information relating to intervention and control description and replicability according to the TIDieR checklist that we used when evaluating the studies Hoffmann 2014. In two of the studies (Bowen 2012, Mackenzie 2014) this was clearly described in sufficient detail for replication. There was less detail in Wenke 2010, although the LSVT intervention used in this study cannot be described as the treatment is trademarked and not available publicly. The Xu 2010 study gave minimal information about the usual care interventions in both arms, and this could not be replicated from the information given but they provided much more detail about the acupuncture delivery. The Kwon 2015 study gave detail around the transcranial magnetic stimulation intervention and how the sham/attention control was carried out. There was no detail around the speech therapy that was given to both groups to ensure they had the same treatment alongside the transcranial magnetic stimulation intervention and sham. There is variation in reporting of whether the intervention was provided correctly to the groups as described in the protocol by those delivering the intervention Table 2. Fidelity of the intervention is not described in Wenke 2010, Xu 2010 or Kwon 2015. Fidelity to the interventions and attention control is described in sufficient detail, including information about how this was monitored, who carried this out, when and how, in Bowen 2012 and Mackenzie 2014. Whether participants completed the intervention in the arm allocated was described in Bowen 2012 and Mackenzie 2014, participants dropping out prior to the intervention was reported in Kwon 2015 but was not specified in Wenke 2010 or Xu 2010. The number of participants lost to follow up assessment was described clearly in Bowen 2012, Mackenzie 2014 and Kwon 2015 and it was reported that none were lost to follow up in Xu 2010 but the information in Wenke 2010 was not clear.

Quality of the evidence

The body of evidence included in this review consists of five studies (234 participants) with all studies having data included in the meta-analysis. We rated the quality of evidence for the key outcomes as low or very low Summary of findings for the main comparison. The primary objective includes 3 studies (116 partici-

pants) Analysis 1.1 and none of these three studies were adequately powered to compare the two interventions with small numbers. The Bowen 2012 study, while adequately powered to look at early communication intervention in aphasia and dysarthria, was not adequately powered to evaluate dysarthria intervention only. These small numbers in all the studies meant the quality of the evidence was downgraded to low and very low. All of the secondary outcomes are downgraded for small participant numbers for imprecision. Only Bowen 2012 and Mackenzie 2014 had low risk of bias and the other three studies all had areas of unclear risk or high risk. The sensitivity analyses were carried out to remove any studies with high or unclear risk of bias but this did not alter the direction or the significance of the results Analysis 1.4.

The one significant finding was from four studies where the overall quality of the evidence was considered very low which raises concerns around how confident we can feel about this estimate of effect Analysis 2.2. In fact, there is considerable uncertainty as all four of the included studies have small participant numbers restricting their statistical power and only two of the five have a low risk of bias. The main message about the quality of the evidence found in this review is that, in addition to being adequately powered, the reporting of RCTs must adhere to the CONSORT guidelines Schulz 2010 and follow the template for intervention description and replication (TIDieR Hoffmann 2014).

Potential biases in the review process

This review was designed to broaden the remit of the inclusion criteria to include trials that may have been carried out by a range of professionals or non-professionals. However, not knowing what potential professional or non-professional group may be carrying out research may introduce the possibility of bias particularly where unpublished literature or ongoing trials were sought, as only those who have worked or are working in the field of dysarthria were approached. The search strategy was in line with this broad approach and the reasons for study exclusions have been documented. The searches were carried out with no time restrictions. The searches were all carried out on English databases, and although we had no language restrictions and had the Chinese paper Xu 2010 translated, this may have restricted our searching method. It is highly probable that foreign language papers were not searched for and this review may be biased towards English-speaking research studies. The Xu 2010 paper written in Chinese had data extraction carried out by two independent Chinese speaking individuals, but neither were involved in the review team so discrepancies with the data extraction from the other papers may have arisen. There was some need for interpretation of the information which may not be entirely as intended by the author. One of our Chinese speaking colleagues did attempt to make email and telephone contact with the author of that paper to request further clarification and information. Where clarification could not be retrieved from any of the authors, information may have been interpreted incorrectly and it is possible that the review is biased until information can be clarified.

The review team has been conscious that one of the authors of the review (AB) was the lead author on one of the papers included in the review. The review team considered how to approach this prior to starting the review in case this study met the inclusion criteria, which as an RCT would be highly likely. The review was structured in a way that ensured the author was not involved in reviewing or making any judgements about their own study. However the author has offered additional information and data where requested and has contributed her opinion to wider discussions where this has been relevant. The review team has been very conscious of the potential for bias and have taken steps to reduce this as much as possible.

Agreements and disagreements with other studies or reviews

A previous review of dysarthria intervention found no suitable studies for inclusion at that time (Sellars 2005). This review has now found five studies for inclusion in the review.

AUTHORS' CONCLUSIONS

Implications for practice

Research evidence is not yet of a sufficient size and quality to guide clinical practice. It is therefore important for clinicians to continue to offer rehabilitation to people with dysarthria in line with current clinical guidelines. This review has shown that there is no evidence to guide the selection of any one treatment over another so clinicians should select interventions they have the skills to deliver that are most appropriate for the individual they are working with considering all aspects of the evidence base regardless of historical or traditional methods.

Implications for research

Further research will need to be appropriately designed with low risk of bias, to evaluate persisting effects on activity level measures. It should also include patients' and carers' views on the available interventions and on the most meaningful way of measuring treatment effects. Patients' and carers' views on acceptability of available interventions and acceptability measures (adherence or satisfaction scales) should be considered in future studies. The absence of evidence for dysarthria interventions certainly highlights the paucity of research for this distressing condition and the need for adequately powered, methodologically sound and well-reported studies. The advance from no studies suitable for inclusion in a Cochrane review to now when we have five completed trials and at least two on-going trials is a positive one, but clearly much

more needs to be done. This research trial inactivity is in striking contrast to aphasia research which has now amassed 57 trials of speech and language therapy intervention for aphasia following stroke Brady 2016.

All future dysarthria trials should have clearly documented evidence of randomisation, allocation concealment, clarity around attrition and evidence of full reporting of all outcomes. Where possible blinding of outcome assessment is desirable, but is not always possible to achieve in rehabilitation research. It is important to consider follow-up and intention-to-treat analysis as this is an important factor in minimising bias. Rehabilitation trialists will find it helpful to adhere to the CONSORT guidelines for all future studies. Future definitive trials must have adequate statistical power to detect clinically meaningful differences and this may be informed by feasibility and pilot trials. It would help if researchers could agree core outcome sets and agreement on time point of measurements. Intervention should be clearly described and replicable and researchers would benefit from adherence to the TIDieR checklist. The involvement of patients and carers in commissioning and designing research would greatly increase the quality of the research discussion especially related to potential interventions and possible outcome measures. There were no studies considering timing, intensity and duration of intervention which is clearly a question of clinical importance and needs to be considered in future research. When considering methodological approaches researchers may want to consider a range of control groups e.g. where intervention is compared to no treatment or alternative treatment or an attention control. These control arms answer different but important questions.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[author-defined order]*

Wenke 2010

Methods	An experimental research design was used to investigate the effects of two treatments at multiple follow up time points
Participants	26 participants in the study. 13 in the TRAD intervention group and 13 in the LSVT intervention group Inclusion criteria were: at least 6 months post onset at the time of inclusion in the study; able to speak and understand English; considered able to increase/alter habitual vocal volume or quality during the pre-treatment assessment Participants were excluded if they presented with a co-existing significant aphasia, hearing loss, dementia, apraxia of speech, post traumatic amnesia, or pre-existing laryngeal pathology and/or dysfunction as identified during a video laryngoscopic examination. Participants with a significant respiratory dysfunction unrelated to the neurological disorder were excluded from the study
Interventions	The TRAD group and LSVT group both had intervention 1 hour a day, 4 days a week for 4 weeks The TRAD group only asked to do homework during the intervention phase an additional 5-10 minutes daily Both TRAD and LSVT asked to do maintenance exercises to be carried out independently following the cessation of treatment for 5-10 minutes a day, 3-5 days a week for 6 months TRAD (traditional dysarthria therapy) used behavioural techniques at impairment and activity level. This involved phonation and/or oro-motor exercises, strategies to improve articulation, respiratory/phonatory therapy, resonance and prosody exercises. Daily 5-10 minutes of homework exercises. Maintenance task of exercises 5-10 minutes a day, 3-5 days a week, for 6 months were given at the end of treatment LSVT treatment was delivered in strict accordance with the manual by a therapist trained in LSVT which employs increased vocal loudness and maximum physiological effort. Maintenance exercises were given following treatment to be carried out for 5-10 minutes a day, 3-5 days a week, for 6 months
Outcomes	No primary outcome measure specified. • Perceptual measure of articulatory precision and intelligibility using direct magnitude estimation • Acoustic analysis of vowels • Acoustic analysis of consonants We used intelligibility measure as primary outcome measure at activity level and articulatory precision as the secondary impairment level measure The data presented in the paper analysed the vowels and consonants separately which meant data extraction was not possible without further information from the authors which we were not able to obtain at the time
Notes	The data from 10 participants in the LSVT group was reported in Wenke, 2008 These data have also been reported in Wenke, 2010 and Wenke, 2011 as well as this paper Wenke, 2010

Wenke 2010 (*Continued*)

	We requested further information and some was provided. We requested a telephone consultation but were unable to progress this further

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Stratified randomisation according to severity levels was carried out and allocation based on the results of this clinical judgement. Computer generated randomisation confirmed by author
Allocation concealment (selection bias)	Unclear risk	Further information suggested a pre-generated list was used and stored on a computer in an Excel file, but it was not clear who had access to this list and how easily accessible this list was
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Two certified speech-language pathologists served as independent listeners. This implies they are not involved in the study but does not specify whether they were blind or not to the intervention
Incomplete outcome data (attrition bias) All outcomes	High risk	Unable to find out more from author, missing outcome data showing imbalance across the two groups
Selective reporting (reporting bias)	Low risk	All outcome measures reported at all time points.

Xu 2010

Methods	To observe the effect of acupuncture combined with speech therapy for dysarthria versus speech therapy only. This study used randomised participants in two groups
Participants	61 cases, 31 in the control group (speech therapy only) and 30 in the intervention group (speech therapy and acupuncture) Inclusion criteria were patients diagnosed with stroke by CT and/or MRI. Patients diagnosed as dysarthric by the hearing and speech specialist Patients excluded were: mother tongue not mandarin, severe dysarthria or dysarthria with aphasia and apraxia of speech, cognitive impairment; could not tolerate speech therapy; parkinsons disease or other cerebellar lesion; myocardial infarction or renal dysfunction, severe infection or severe diabetes; unable to tolerate acupuncture, or having syncope; do not meet the inclusion criteria

Xu 2010 (*Continued*)

Interventions	The speech therapy for both groups was delivered by a specialist, carried out in 30 minute sessions, 5 times a week for 9 weeks Speech therapy intervention for both groups is impairment and activity level intervention. Breathing training, articulation work, nasality work, tone and intonation The intervention group also had acupuncture. The acupuncture was delivered for 30 minutes at a time, 5 times a week and 20 times. There were 2 courses during the 9 week period
Outcomes	No primary outcome measure identified. Outcome measures were; • Perceptual evaluation of articulation intelligibility using the Chinese Rehabilitation Research Centre Dysrthria Examination method. • The maximum phonation time measuring air flow Outcome measures carried out immediately post treatment when the 9 week treatment period ended
Notes	Contact with the author was attempted through a Chinese speaking colleague but the author was not in a position to respond to the queries at that time and there was no further information provided. The author is welcome to make contact with the review team

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	This refers to a random number table but limited information make this judgment difficult
Allocation concealment (selection bias)	Unclear risk	There is no information around allocation concealment without further discussion with the author of the study
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	The patients were tested before and after the treatment by the same hearing and speech therapist who didn't know the detail of the trial. This implies they were blinded to the intervention but no further information
Incomplete outcome data (attrition bias) All outcomes	Low risk	Appears to have no missing data with all patients recruited remaining in the trial to follow up
Selective reporting (reporting bias)	Unclear risk	Need further clarification from author.

Bowen 2012

Methods	This study was an externally randomised, pragmatic, parallel, superiority trial with blinded outcome assessment This was a larger trial of all communication impairments following stroke and the dysarthria population was a planned subgroup from this larger trial. We were able to extract the data for the dysarthria population from this larger trial
Participants	66 patients with dysarthria (from the larger trial which had a total number of people recruited with aphasia and/or dysarthria = 17[illegible] 32 in the control group and 34 in the intervention group. This was a trial of early intervention so participants were within the first four months post stroke **Inclusion criteria of the trial** Adults with a stroke who were admitted to hospital were eligible for inclusion if they met the following criteria: • communication impaired due to aphasia or dysarthria. • considered, by the speech and language therapist, able to engage in therapy. • considered, by the speech and language therapist, likely to benefit from communication therapy • informed consent or proxy consent provided by carers. **Exclusion criteria of the trial** • Subarachnoid haemorrhage. • Dementia • Pre existing learning disabilities likely to prevent benefit from therapy. • Unable to communicate in the English language. • Other serious concomitant medication conditions. • Patient unable to complete eligibility screening after 3 attempts over 2-week period. • Family or carer objections. • Case when a speech and language therapist was asked to contribute to an urgent assessment of a person's mental capacity to consent to an NHS treatment, before the therapist had time to complete screening to determine eligibility for the trial.
Interventions	ACT NoW speech and language therapy or attention control for up to 4 months. In both interventions participants were seen up to three times per week for a maximum of four months In the speech therapy intervention participants were seen by a highly qualified speech and language therapist ACTNoW therapy: • intervention started approximately 2 weeks after admission to hospital • lasted a maximum of 16 weeks with three contacts per week - but this was variable • intervention took place in a number of settings as appropriate to the patient's care pathway • intervention was designed, implemented and monitored by qualified SLT, employed by NHS trusts. SLTs delivered most of the one-to-one contacts but some were delivered by supervised assistants. • intervention was multifaceted and tailored to individual needs, but consisted of 6 core components i) assessment & information gathering, using standardised methods ii) information provision regarding communication difficulties, intervention goals, progress, etc

	iii) communication materials to record interventions & activities, plus provision of AAC devices as appropriate iv) information and training for carers v) indirect contact with MDT colleagues regarding patient needs vi) one-to-one contact involving intervention for speech and language impairment, psychosocial impacts, activities, etc. as appropriate to the individual. The dysarthria intervention delivered was classified according to impairment type including: Impairment (97%), activity (61%), participation (61%) Attention Control: The attention control was delivered by visitors, employed to carry out structured social contact. Education background is detailed • intervention started approximately 2 weeks after admission to hospital • lasted a maximum of 16 weeks with three contacts per week - but this was variable • intervention took place in a number of settings as appropriate to the patient's care pathway • planned and implemented by part time staff employed for the study, with no prior experience or specific training in stroke rehabilitation • sessions were 60 minutes maximum duration and tailored to individual needs, with activities being participant led. Sessions consisted of three stages: i) building rapport and getting to know each other, finding common group ii) regular contact sessions including general conversation and activities iii) winding down sessions
Outcomes	Primary outcome: blinded, functional communicative ability assessed on the Therapy Outcome Measure activity sub-scale (TOM). A conversation with an unfamiliar conversation partner was rated using the TOM by an expert independent expert SLT Secondary outcomes: i) participants' perception on the Communication Outcomes After Stroke scale (COAST); ii) carer's perceptions of participants from part of the Care COAST; iii) carer well-being on Carers of Older People in Europe Index; iv) quality of life items from Carer COAST; v) serious adverse events; vi) economic evaluation, vii) participants' utility (European Quality of LIfe-5 Dimensions) Outcomes were evaluated at baseline and 6 months post randomisation, with 2 month gap between completion of intervention and final assessment
Notes	Primary outcome reported for sub-groups of diagnosis (i.e. aphasia, dysarthria); secondary outcomes not reported separately We have ensured AB, author of this trial and involved in this Cochrane review, has had no involvement in the review of this paper but she has contributed her opinion and additional information. Additional data was requested and provided for this study

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation by an external, independent, web-based randomisation service using a computer generated string of random permitted blocks. Participants were

Bowen 2012 (*Continued*)

		randomised using a 1:1 allocation ratio and block sizes of two, four and six with different combinations depending on site and stratified according to severity and study centre. Block sizes were not known
Allocation concealment (selection bias)	Low risk	External, independent, web-based
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Outcome assessment carried out by an independent speech and language therapist, blinded to treatment allocation and not involved in treating study participants
Incomplete outcome data (attrition bias) All outcomes	Low risk	ITT employed
Selective reporting (reporting bias)	Low risk	Study protocol available and all statistical data included fully in the report

Mackenzie 2014

Methods	A feasibility randomised controlled trial
Participants	Recruited 39 participants with dysarthria and 32 retained to follow up Group A had 20 participants and group B had 19 participants. Inclusion criteria were: minimum of 3 months since the last stroke; no co-existing neurological conclusion; dysarthria, with articulatory imprecision, diagnosed by a referring SLT; Mini Mental State Examination score more than or equal to 24; Boston Diagnostic Aphasia Examination aphasia severity rating of 4-5; community residence at time of intervention; first language English and vision and hearing adequate, with any required augmentation, for reception of spoken stimuli, following instructions, and reading enlarged stimulus material, as informally judged by self-report and by referring SLT
Interventions	Both groups received eight once weekly SLT led sessions of around 40 minutes Group A and group B both had the following intervention of behavioural, activity level practice of individually relevant speech sounds in words, sentences and conversation. Strategies for optimising speech, slowed rate, emphasis of key syllables, deliberate articulation were also used as required Group A carried out 20 minutes of word and sentence practice as part of the 40 minute session Group B also had non-speech oro-motor exercises (impairment level) and carried out 10 minutes of word and sentence practice and 10 minutes of oro-motor exercises as part of the 40 minute session
Outcomes	No primary outcome measure identified in this feasibility trial The outcome measures used were; • Speech intelligibility at sentence level with Speech Intelligibility Test (SIT; Yorkston et al. 1996). • Communication effectiveness in conversation with Communication Effectiveness

	Measure (CEM; Mackenzie and Lowit 2007) • Lip and tongue movement tasks from Frenchay Dysarthria Assessment-2 (FDA-2; Enderby and Palmer 2008)
Notes	Further information was requested and provided for this study as well as a telephone consultation We were able to classify incomplete outcome data as low risk following discussion with the author. They clarified that they had statistically analysed their findings appropriately and this had not affected the results "Group A versus Group B difference was not indicated on any of the four measures, based on data for 32 completing participants: SIT F(1, 30)=1.46, p=0.24; CEM F(1, 30) = 2.39, p = 0.13, CES F(1, 30) = 0.58, p = 0.45; FDA-2 F(1, 30) = 2.61, p = [illegible] There was no significant interaction between group allocation and assessment point on any of the four measures for these participants: SIT F(3, 90) = 0.88, p = 0.97; CEM F(3, 90) = 0.34, p = 0.80; CES F(3, 90) = 0.16, p = 0.92; FDA F(3, 90) = 0.12, p = 0.95. In view of the scale nature of the CEM measure, non-parametric analysis was also undertaken and provided similar results. Imputation of results for seven additional cases with incomplete intervention and/or post-intervention assessments, by last observation carried forward and multiple imputation provided similar results for all measures."

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Randomisation was computer generated and the block system was employed to facilitate the logistics of recruitment and intervention. This would not affect sequence generation. Patients were referred in batches of 8 and then randomised within each block so 4 to group A and 4 to group B
Allocation concealment (selection bias)	Low risk	This was provided in opaque envelopes after the initial assessment by the 'assessor' and just before the intervention treatment started by the 'intervention' researcher
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Single blinded experienced SLT research assessor collected the outcome measurements. These were rated or transcribed by groups of blinded graduating SLT students

Mackenzie 2014 (*Continued*)

Incomplete outcome data (attrition bias) All outcomes	Low risk	Missing outcome not likely to clinically impact, discussed with author and confirmed all data included and adjusted where appropriate
Selective reporting (reporting bias)	Low risk	Feasibility study but all data and outcomes reported.

Kwon 2015

Methods	Single centre, prospective, randomised, double-blind, sham stimulation-controlled trial
Participants	A total of 42 patients were initially enrolled in this study, but 17 were excluded after being assessed for eligibility. Among the excluded patients, 11 did not meet the inclusion criteria and six refused to participate. A final total of 25 post-stroke patients were therefore recruited and randomized to the two study groups. Twenty of these patients completed the study. Three and two patients were unable to complete the study in the rTMS and sham stimulation groups, respectively . Ten patients each completed the rTMS and sham stimulation groups Inclusion and exclusion criteria: First-ever unilateral middle cerebral artery infarction. Duration from stroke onset ranged from 1 week to 2 months but all had experienced their first ever stroke. Dysarthria was evaluated by a single skilled speech therapist who was blind to the study protocol Patients were evaluated for cognitive and speech function and patients who had aphasia, apraxia or speech, cognitive impairment (MMSE<20)), poor mental status, vocal cord palsy, history of epilepsy, or bilateral infarction were excluded
Interventions	This procedure was carried out as part of the intervention to establish motor evoked potentials. To determine the resting motor threshold and stimulation area, we recorded motor-evoked potentials from the orbicularis oris muscles on each patient's non-affected side using transcranial magnetic stimulation. Focal transcranial magnetic stimulation was applied using a Magstim Rapid magnetic stimulator (Magstim Company Ltd., Dyfed, UK). Briefly, a Magstim circular coil (external diameter, 90 mm) was placed onto each subject's contralateral motor cortex to identify the hotspot, defined as the area that produced the largest amplitude of motor-evoked potentials. The resting motor threshold was defined as the stimulus intensity required to produce motor-evoked potentials >100 kV at a peak-to-peak amplitude during three of five consecutive trials on the orbicularis oris. This was carried out by a 'physiatrist'. The experimental intervention was LF stimulation which involved being seated in a comfortable chair with foam ear plugs, each patient was treated with 10 consecutive sessions (five times per week for 2 weeks) of rTMS, performed by a physiatrist who used a 70-mm, aircooled, figure-of-eight Y-shaped coil. We performed rTMS at a low frequency (1 Hz), at 90% amplitude of evoked motor threshold, and with 1,500 stimulations/day on the hotspot This group also received speech therapy for 30 minutes, 5 days a week from a skilled speech therapist who was blind to the nature of the study during the 2-week intervention period The sham stimulation occurred using the same protocol as that for the LF stimulation,

	except that the angle of the coil was perpendicular to the skull rather that tangential to it. Thus, the magnetic field could not penetrate the brain, although the subjects could hear the sound that was produced This group also received speech therapy for 30 minutes 5 days a week from a skilled speech therapist who was blind to the nature of the study during the 2-week intervention period
Outcomes	No primary outcome identified. 1. Urimal Test of Articulation and phonology (U-TAP) 2. Alternative motion rates (AMR) 3. Sequential motion rates (SMR) 4. Maximal phonation time (MPT) These four measures were carried out immediately at the end of the two week treatment period
Notes	The corresponding author reports the first author has left the department so cannot discuss this study further. The author is welcome to contact the review team to offer clarification about the study

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Randomization was done according to a table of random numbers; odd numbers went to the rTMS group and even numbers went to the sham stimulation group although it doesn't specify if this was equal randomisation. Insufficient information
Allocation concealment (selection bias)	Unclear risk	No description of what method was used to ensure allocation concealment so this indicates a potential risk without further information
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Study reports outcome assessor was blinded to protocol but insufficient detail as to how this was ensured it may have been easy to break this blinding process
Incomplete outcome data (attrition bias) All outcomes	High risk	Five participants were randomised to treatment groups but then failed to complete the treatment. These participants and their data were withdrawn from all the analysis and no consideration evident as to how this missing data was dealt with
Selective reporting (reporting bias)	Unclear risk	In the absence of a protocol this remains unclear

Characteristics of excluded studies *[ordered by year of study]*

Study	Reason for exclusion
Nagasawa 1970	Not a randomised controlled trial
Jones 1972	Not a randomised controlled trial
Markov 1973	Not a randomised controlled trial
Katic 1973	Not a randomised controlled trial
Ince 1973	Not a randomised controlled trial
Huffman 1978	Not a randomised controlled trial
Fukusako 1989	Not a randomised controlled trial
Cohen 1993	mixed aetiology of progressive and non-progressive, adult acquired and congenital brain injury
Main 1998	Different aetiologies included
Garcia 1998	Not a randomised controlled trial
Braverman 1999	Randomised controlled trial included patients with communication problems other than dysarthria Intervention for cognition not dysarthria
Kelly 2000	Different aetiologies included
Robertson 2001	Not randomised controlled trial
Qinglan 2002	Intervention surgical this was excluded
Sze 2002	Intervention not for dysarthria
Hustad 2003	Not a randomised controlled trial
Varma 2004	Not a randomised controlled trial
Togher 2004	Intervention not for dysarthria and different population
Palmer 2004	Not a randomised controlled trial
Rosenbek 2006	Not a randomised controlled trial
Palmer 2007	Not a randomised controlled trial
Fitzgerald-DeJean 2008	Not a randomised controlled trial and language intervention

(*Continued*)

Behn 2011	Exclusion criteria included presence of dysarthria
Behn 2012	Intervention for carers not for dysarthria
Sakharov 2013	Not a randomised controlled trial
Li 2013	Not a randomised trial
Togher 2014	Not a randomised controlled trial
Huh 2014	Not a randomised controlled trial

Characteristics of studies awaiting assessment *[ordered by study ID]*

You 2010

Methods	The effects of transcranial direct stimulation on dysarthria in stroke patients In a prospective, double blinded, randomised case control study performed between January 2007 and December 2008, six patients were randomised to anodal tDCS application and conventional speech therapy, and six patients were randomised to the sham group which received only conventional speech therapy. tDCS was delivered for 30 minutes at 2 mA with 25cm2, five times/week for a total two weeks. The effects were assessed in maximal phonation time (MPT), alternative motion rates (AMR)-Pa, AMR-Ta, AMR-Ka, and sequential motion rates (SMR)-PaTaKa using the Multi-Media Dimensic Voice Program
Participants	Twelve patients who developed dysarthria after acute middle cerebral artery (MCA) infarction were included in this study
Interventions	Experimental intervention nodal tDCS application and conventional speech therapy Usual care intervention was conventional speech therapy only
Outcomes	Pre-treatment patient evaluation showed no significant difference between the two groups for all parameters. The MPT, AMR-Pa, AMR-Ta, AMR-Ka, and SMR-PaTaKa were improved pre- and post-treatment in the stimulation group, while MPT, SMR-PaTaKa were improved in the sham group ($p < 0.05$). The AMR-Pa significantly improved in the stimulation group compared to the sham group ($p < 0.05$)
Notes	This study is written in Korean and this paper needs to be fully translated and data extracted before it can be considered for inclusion in the review The corresponding author reports the first author has left the department so cannot discuss this study further. The author is welcome to contact the review team to offer clarification about the study

Characteristics of ongoing studies *[ordered by study ID]*

Peng 2015

Trial name or title	Modified VitalStim electroacupuncture improves the speech function in patients with spastic dysarthria after stroke
Methods	32 patients with spastic dysarthria after stroke within one month were randomly divided into VitalStim group (n = 16) and control group (n = 16). Basic medical therapy, physical therapy, occupational therapy, and speech therapy were used in both group. Additionally, modified VitalStim electroacupuncture at acupoints of Yiming (EXHN14), Fengchi (GB20), Dazhui (BU14), Lianquan (RN23), Baihui (DU20) and lateral Jinjinyuye was performed in Vitalstim group. Patients in VitalStim group received extra 30-minute VitalStim therapy once a day, for a total of 28 days. The outcomes were evaluated by using modified Barthel index (MBI) and Frenchay dysarthria assessment (FDA). And the practical significance of VitalStim electroacupuncture were statistical analyzed
Participants	32 patients with spastic dysarthria after stroke within one month
Interventions	Basic medical therapy, physical therapy, occupational therapy, and speech therapy were used in both groups Additionally, modified VitalStim electroacupuncture at acupoints of Yiming (EXHN14), Fengchi (GB20), Dazhui (BU14), Lianquan (RN23), Baihui (DU20) and lateral Jinjinyuye was performed in Vitalstim group. Patients in VitalStim group received extra 30-minute VitalStim therapy once a day for a total of 28 days
Outcomes	The outcomes were evaluated by using modified Barthel index (MBI) and Frenchay dysarthria assessment (FDA). MBI increased significantly after treatment in both groups ($P < 0.01$). Compared with both groups, MBI increased more significantly in VitalStim group ($P < 0.05$). Significant improvements were found in VitalStim group in relation to 20 FDA items, such as lips spread, tongue at rest and palate maintenance ($P < 0.05$). The performance of the patients in VitalStim group on the rest of FDA items also showed an improvement trend compared with that of control ($P > 0.05$) except for the two items in relation to tongue alternate and jaw in speech
Starting date	Not known
Contact information	Y.N. Peng, Y.Yin1,2, B.T. Tan 1, W. Jiang 1, B. Zheng1, Y.Y. Deng1, L. f. Yu 1,2 1 The Second Affiliated Hospital of Chongqing Medical University, Rehabilitation Medicine, Chongqing, China; 2 Chongqing Medical University, Rehabilitation Therapy, Chongqing, China
Notes	This study is in an abstract form only but no full report can be found. We have attempted to make contact with the authors to retrieve further information about this study and to find out if it has been written up and accepted for publication as a full paper. The authors are welcome to make contact to provide further information about the full study publication progress WCPT Congress 2015 / Physiotherapy 2015; Volume 101, Supplement 1 eS833-eS1237 eS1189 Ethics approval: Ethical approval obtained from the Ethics Committee of the second Affiliated Hospital of Chongqing Medical University. http://dx.doi.org/10.1016/j.physio.2015.03.2113 Research Report Poster Presentation

ReaDySpeech

Trial name or title	**ReaDySpeech for people with dysarthria after stroke: protocol for a feasibility randomised controlled trial**
Methods	A feasibility, randomised controlled trial, will recruit 36 people with post-stroke dysarthria who are more than one week post stroke. Participants will be externally randomised in 2:1 ratio to receive either ReaDySpeech and usual care (24 participants) or usual care only (12 participants). This study is single blind with the researcher carrying out the baseline and outcome measures blinded to treatment allocation. The primary objective is to assess the feasibility of conducting a definitive trial. Secondary objectives include recruitment rate, and determining: numbers of eligible patients recruited and reasons for non-recruitment; loss of participants to follow up and reasons; acceptability of randomisation and the intervention; adherence to the intervention; acceptability of outcome measures; defining 'usual' care; and, the implications of the intervention for the patient/family/carer
Participants	The study population includes adults, (aged ≥18 years) with dysarthria as a result of stroke
Interventions	ReaDySpeech is an online programme which delivers articulation exercises to improve breathing; intonation; facial expression; rate of speech; oro-motor control (including range of movement, strength and speed) . ReaDySpeech is set up and amended by the treating therapist according to the patient's progress. The patient accesses these exercises online using any Wi-Fi enabled device (smart phone, tablet computer, lap top computer or personal computer). It can be used in a variety of ways: as part of face to face therapy during a session with a speech and language therapist or a therapy assistant, or the patient can use it independently outside of the therapy sessions, with or without the support of family or carers. The therapists select clinically relevant exercises and negotiate agreed intensity and duration of use with the patient, adherence to which is monitored by the software programme which will record the exercises selected by the therapist. Therapists will have an instruction booklet with screen shots to support their use of ReaDySpeech. Our proof of concept work has shown that ReaDySpeech can be delivered by any qualified speech and language therapist of any level of experience. In this trial participating therapists will use ReaDySpeech with patients who meet the inclusion criteria alongside 'usual' care for a maximum of 10 weeks. No specifications about the intensity of ReaDySpeech care will be made and this will be decided according to the therapists' clinical judgement in consultation with the patient
Outcomes	Primary outcome: Dysarthria Therapy Outcome Measure (Therapist reported activity level measure) Secondary outcomes: COAST, communication outcome after stroke scale, Dysarthria impact profile (Patient reported outcome measure, activity & participation level), Frenchay Dysarthria Assessment 2nd edition (Therapist reported impairment level measure); Euroquol 5D-5L (Patient reported generic health outcome measure)
Starting date	September 2015
Contact information	claire.mitchell@manchester.ac.uk
Notes	ISRCTN84996500

DATA AND ANALYSES

Comparison 1. Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level	3	116	Std. Mean Difference (IV, Random, 95% CI)	0.18 [-0.18, 0.55]
2 Secondary outcome of dysarthria intervention versus any control: persisting effects, impairment level	2	56	Std. Mean Difference (IV, Random, 95% CI)	0.07 [-0.91, 1.06]
3 Secondary outcome of dysarthria intervention versus any control: persisting effects, participation level	2	79	Std. Mean Difference (IV, Random, 95% CI)	-0.11 [-0.56, 0.33]
4 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level: adequate allocation concealment/adequate blinding	2	92	Std. Mean Difference (IV, Random, 95% CI)	0.21 [-0.30, 0.73]
5 Secondary outcome of dysarthria intervention versus attention control, placebo or no intervention: persisting effects, activity level	1	60	Std. Mean Difference (IV, Random, 95% CI)	0.0 [-0.51, 0.51]
6 Secondary outcome of dysarthria intervention versus any control for stroke sub-group: persisting effects, activity level	3	106	Std. Mean Difference (IV, Random, 95% CI)	0.16 [-0.23, 0.54]

Comparison 2. Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Seconday outcome of dysarthria intervention versus any control: immediate effects, activity level	3	117	Std. Mean Difference (IV, Random, 95% CI)	0.29 [-0.07, 0.66]
2 Secondary outcome of dysarthria intervention versus any control: immediate effects, impairment level	4	99	Std. Mean Difference (IV, Random, 95% CI)	0.47 [0.02, 0.92]

3 Secondary outcome of dysarthria intervention versus any control: immediate effects, participation level	1	32	Std. Mean Difference (IV, Random, 95% CI)	-0.24 [-0.94, 0.45]

Comparison 3. Dysarthria intervention A versus dysarthria intervention B: Persisting and immediate effects

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, activity level	2	56	Std. Mean Difference (IV, Random, 95% CI)	0.38 [-0.15, 0.91]
2 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, participation level	1	32	Std. Mean Difference (IV, Random, 95% CI)	-0.22 [-0.92, 0.47]

Analysis 1.1. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 1 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

Outcome: 1 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level

Study or subgroup	Any control N	Mean (SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Bowen 2012	33	3.1 (1.4)	27	3.1 (1.7)		52.2 %	0.0 [-0.51, 0.51]
Mackenzie 2014		4.92 (1.44)	16	4.09 (1.56)		27.0 %	0.54 [-0.17, 1.25]
Wenke 2010	3	121.4 (36.4)	11	110.25 (79.9)		20.8 %	0.18 [-0.63, 0.98]
Total (95% CI)	**6**		**54**			**100.0 %**	**0.18 [-0.18, 0.55]**

Heterogeneity: Tau² = 0.0; Chi² = 1.47, df = 2 (P = 0.48); I² =0.0%

Test for overall effect: Z = 0.97 (P = 0.33)

Test for subgroup differences: Not applicable

Analysis 1.2. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 2 Secondary outcome of dysarthria intervention versus any control: persisting effects, impairment level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

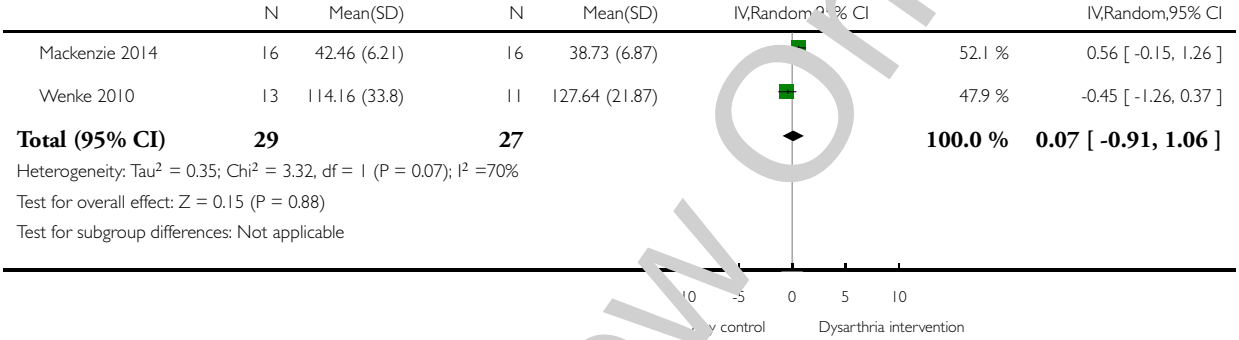
Outcome: 2 Secondary outcome of dysarthria intervention versus any control: persisting effects, impairment level

Study or subgroup	Dysarthria interven-tion N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Mackenzie 2014	16	42.46 (6.21)	16	38.73 (6.87)		52.1 %	0.56 [-0.15, 1.26]
Wenke 2010	13	114.16 (33.8)	11	127.64 (21.87)		47.9 %	-0.45 [-1.26, 0.37]
Total (95% CI)	**29**		**27**			**100.0 %**	**0.07 [-0.91, 1.06]**

Heterogeneity: $Tau^2 = 0.35$; $Chi^2 = 3.32$, df = 1 (P = 0.07); $I^2 = 70\%$

Test for overall effect: Z = 0.15 (P = 0.88)

Test for subgroup differences: Not applicable



Analysis 1.3. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 3 Secondary outcome of dysarthria intervention versus any control: persisting effects, participation level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

Outcome: 3 Secondary outcome of dysarthria intervention versus any control: persisting effects, participation level

Study or subgroup	Dysarthria interven-tion		Any control		Std. Mean Differen…	Weigh…	Std. Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Random,95% CI		IV,Random,95% CI
Bowen 2012	28	74.523 (19.233)	19	75.18 (12.96169)		58.8 %	-0.04 [-0.62, 0.54]
Mackenzie 2014	16	19.94 (5.97)	16	21.25 (5.48)		41.2 %	-0.22 [-0.92, 0.47]
Total (95% CI)	**44**		**35**			**100.0 %**	**-0.11 [-0.56, 0.33]**

Heterogeneity: Tau² = 0.0; Chi² = 0.16, df = 1 (P = 0.69); I² =0.0%

Test for overall effect: Z = 0.50 (P = 0.62)

Test for subgroup differences: Not applicable

Analysis 1.4. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 4 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level: adequate allocation concealment/adequate blinding.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

Outcome: 4 Primary outcome of dysarthria intervention versus any control: persisting effects, activity level: adequate allocation concealment/adequate blinding

Study or subgroup	Dysarthria intervention N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Bowen 2012	33	3.1 (1.4)	27	3.1 (1.7)		60.8 %	0.0 [-0.51, 0.51]
Mackenzie 2014	16	4.92 (1.44)	16	4.09 (1.56)		39.2 %	0.54 [-0.17, 1.25]
Total (95% CI)	**49**		**43**			**100.0 %**	**0.21 [-0.30, 0.73]**

Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 1.47$, df = 1 (P = 0.23); $I^2 = 32\%$

Test for overall effect: Z = 0.80 (P = 0.42)

Test for subgroup differences: Not applicable

Analysis 1.5. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 5 Secondary outcome of dysarthria intervention versus attention control, placebo or no intervention: persisting effects, activity level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

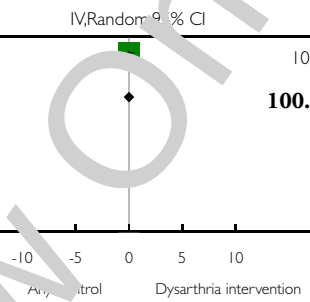
Outcome: 5 Secondary outcome of dysarthria intervention versus attention control, placebo or no intervention: persisting effects, activity level

Study or subgroup	Dysarthria intervention N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Bowen 2012	33	3.1 (1.4)	27	3.1 (1.7)		100.0 %	0.0 [-0.51, 0.51]
Total (95% CI)	**33**		**27**			**100.0 %**	**0.0 [-0.51, 0.51]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.0 (P = 1.0)

Test for subgroup differences: Not applicable



Analysis 1.6. Comparison 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects, Outcome 6 Secondary outcome of dysarthria intervention versus any control for stroke sub-group: persisting effects, activity level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 1 Dysarthria intervention compared to another intervention, attention control, placebo or no intervention: Persisting effects

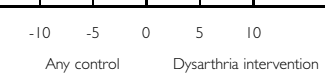
Outcome: 6 Secondary outcome of dysarthria intervention versus any control for stroke sub-group: persisting effects, activity level

Study or subgroup	Dysarthria intervention N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Bowen 2012	33	3.1 (1.4)	27	3.1 (1.7)		57.2 %	0.0 [-0.51, 0.51]
Mackenzie 2014	16	4.92 (1.44)	16	4.09 (1.56)		29.6 %	0.54 [-0.17, 1.25]
Wenke 2010	129.6667 (59.815)		6	8	131.63 (58.70979)	13.2 %	-0.03 [-1.09, 1.03]
Total (95% CI)	**55**		**51**			**100.0 %**	**0.16 [-0.23, 0.54]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 1.61$, df = 2 (P = 0.45); $I^2 = 0.0\%$

Test for overall effect: Z = 0.79 (P = 0.43)

Test for subgroup differences: Not applicable



Analysis 2.1. Comparison 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects, Outcome 1 Seconday outcome of dysarthria intervention versus any control: immediate effects, activity level

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects

Outcome: 1 Seconday outcome of dysarthria intervention versus any control: immediate effects, activity level

Study or subgroup	Dysarthria intervention N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Mackenzie 2014	16	4.93 (1.48)	16	4.1 (1.7)		26.7 %	0.53 [-0.18, 1.24]
Wenke 2010	13	102.14 (30.07)	11	9[illegible].23 (5[illegible].31)		20.7 %	0.13 [-0.67, 0.94]
Xu 2010	30	55.83 (15.26)	31	52[illegible] (14.65		52.6 %	0.24 [-0.27, 0.74]
Total (95% CI)	**59**		[illegible]			**100.0 %**	**0.29 [-0.07, 0.66]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.64$, df = 2 (P = 0.73); $I^2 = 0.0\%$

Test for overall effect: Z = 1.57 (P = 0.12)

Test for subgroup differences: Not applicable

Analysis 2.2. Comparison 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects, Outcome 2 Secondary outcome of dysarthria intervention versus any control: immediate effects, impairment level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects

Outcome: 2 Secondary outcome of dysarthria intervention versus any control: immediate effects, impairment level

Study or subgroup	Dysarthria interven-tion N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Kwon 2015	10	100 (0)	10	98.1 (4.7)			Not estimable
Mackenzie 2014	16	41.36 (6.4)	16	37.06 (6.58)		39.8 %	0.65 [-0.07, 1.36]
Wenke 2010	13	110.28 (27.54)	11	102.28 (52.39)		31.2 %	0.19 [-0.62, 0.99]
Xu 2010	12	8.84 (3.03)	11	7.3 (2.37)		29.0 %	0.54 [-0.29, 1.38]
Total (95% CI)	**51**		**48**			**100.0 %**	**0.47 [0.02, 0.92]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.73$, df = 2 (P = 0.69); $I^2 = 0.0\%$

Test for overall effect: Z = 2.06 (P = 0.039)

Test for subgroup differences: Not applicable

Analysis 2.3. Comparison 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects, Outcome 3 Secondary outcome of dysarthria intervention versus any control: immediate effects, participation level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 2 Dysarthria Intervention compared to another intervention, attention control, placebo or no intervention: Immediate effects

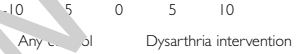
Outcome: 3 Secondary outcome of dysarthria intervention versus any control: immediate effects, participation level

Study or subgroup	Dysarthria interven-tion N	Mean(SD)	Any control N	Mean(SD)	Std. Mean Difference IV,Random,95% CI	Weight	Std. Mean Difference IV,Random,95% CI
Mackenzie 2014	16	20.13 (6.53)	16	21.56 (4.8)		100.0 %	-0.24 [-0.94, 0.45]
Total (95% CI)	**16**		**16**			**100.0 %**	**-0.24 [-0.94, 0.45]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.69 (P = 0.49)

Test for subgroup differences: Not applicable



Analysis 3.1. Comparison 3 Dysarthria intervention A versus dysarthria intervention B: Persisting and immediate effects, Outcome 1 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, activity level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 3 Dysarthria intervention A versus dysarthria intervention B: Persisting and immediate effects

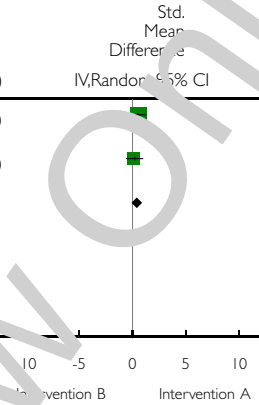
Outcome: 1 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, activity level

Study or subgroup	Intervention A		Intervention B		Std. Mean Difference	Weight	Std. Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Random,95% CI		IV,Random,95% CI
Mackenzie 2014	16	4.92 (1.44)	16	4.09 (1.56)		56.4 %	0.54 [-0.17, 1.25]
Wenke 2010	13	121.4 (36.4)	11	110.25 (79.9)		43.6 %	0.18 [-0.63, 0.98]
Total (95% CI)	**29**		**27**			**100.0 %**	**0.38 [-0.15, 0.91]**

Heterogeneity: $Tau^2 = 0.0$; $Chi^2 = 0.43$, df = 1 (P = 0.51); $I^2 = 0.0\%$

Test for overall effect: Z = 1.41 (P = 0.16)

Test for subgroup differences: Not applicable



Analysis 3.2. Comparison 3 Dysarthria intervention A versus dysarthria intervention B: Persisting and immediate effects, Outcome 2 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, participation level.

Review: Interventions for dysarthria due to stroke and other adult-acquired, non-progressive brain injury

Comparison: 3 Dysarthria intervention A versus dysarthria intervention B: Persisting and immediate effects

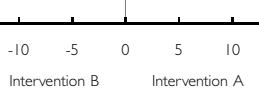
Outcome: 2 Secondary outcome of dysarthria intervention A versus dysarthria intervention B: persisting effects, participation level

Study or subgroup	Intervention A		Intervention B		Std. Mean Difference	Weight	Std. Mean Difference
	N	Mean(SD)	N	Mean(SD)	IV,Random,95% CI		IV,Random,95% CI
Mackenzie 2014	16	19.94 (5.97)	16	21.25 (5.48)		100.0 %	-0.22 [-0.92, 0.47]
Total (95% CI)	**16**		**16**			**100.0 %**	**-0.22 [-0.92, 0.47]**

Heterogeneity: not applicable

Test for overall effect: Z = 0.63 (P = 0.53)

Test for subgroup differences: Not applicable



ADDITIONAL TABLES

Table 1. Characteristics of participants in included studies

Study	Participant numbers randomised	Male/female	Age in years Mean±SD (range)	Time post stroke/brain injury	Dysarthria severity	Other impairment,communication/cognition
Kwon 2015	25	Intervention 10/0 Attention Control 7/3	Int. 69.4±11.8 AC 68.8±9.8	Int. in days 26.±15.0 AC in days 26.5±12.7	Not reported	Excluded from study
Mackenzie 2014	39	Intervention A 12/7 Intervention B 14/6 (usual care)	Int. A 62.80±12.52 Int. B 67.95±11.10	Int. A in months 9.84±7.09 Int. B in months 9.3±5.12	Int. A mild 12/severe 7 Int. B mild 9/severe 11	Int. A 6 of 19 had aphasia Int B. 6 of 20 had aphasia
Bowen 2012	66	Intervention 27/7 Attention Control 20/12	Int. 70±11.4 AC 67±11.8	Within first 4 months post stroke Both groups median time from stroke to randomisation 12 days	53% severe dysarthria, both groups	Int. 25 of 34 had aphasia AC 24 of 32 had aphasia
Wenke 2010	26	Intervention A 7/6 Intervention B 9/4 (Usual care)	Total study 48.6±21.3	Total study in years 3.4±4.75 (range.5-21 years)	Int. A mild/moderate 7 moderate/severe 6 Int. B mild/moderate 7 moderate/severe 6	Int. A cognitive impairment 11 of 13 Int. B cognitive impairment 10 of 13
Xu 2010	51	Intervention A 23/7 Intervention B 26/5 (usual care)	Int. A 52.6±12.7 Int. B 52.2±12.3	Int. A in months 2.80±2.13 Int. B in months 2.48±1.69	Severe dysarthria excluded	Excluded from study

Table 2. Characteristics of interventions in included studies

Study	Dropouts by intervention	Adherence to intervention	Intervention delivered by	Fidelity of intervention	Timing of intervention post stroke/brain injury	Duration of intervention	Frequency of intervention	Home practice
Kwon 2015	25 randomised Intervention lost 3/13 Attention Control lost 2/12	20 completed intervention	Physiatrist	Not described	Between 1 week - 2 months	3 weeks	30 minutes 5 days a week	None
Mackenzie 2014	39 randomised Int A lost 4/19 to follow up Int B (usual care) lost 4/20 to follow up	Int A 17/19 completed Int B 19/20 completed	Single experienced SLT	Monitored by research team and health boards at 2 sessions.	More than 3 months	8 weeks	40 minutes once a week	10-15 mins, 5 days a week (1050 minutes) Recorded in diary 85% practised 1050 minutes
Bowen 2012	66 randomised Int lost 4/34 AC lost 8/32	Int A 33/34 completed AC 27/32 completed	Int A 45% contacts experienced therapist 55% contacts less experienced therapist AC employed, part-time visitors with high level educational attainment	Int A direct monitoring of therapy sessions, case notes, goal setting audit by experienced therapist involved in study AC monitor trained visitors, supervised and monitored sessions according to protocol	Less than 16 weeks	No more than 16 weeks of intervention	Int A as required mean 15 hours, 20 contacts AC 15 hours, 19 contacts	None
Wenke 2010	26 randomised Int A lost 4/13 to some follow up as-	Int A all completed Int B all completed	Speech pathologist certified in intervention	Not described	More than 6 months	4 weeks	Int A 1 hour a day 4 days a week Int B 1 hour	Int B only asked to practice 5-10 mins

Table 2. Characteristics of interventions in included studies (*Continued*)

	sessments Int B (Usual care) lost 4/13 to some follow up assessments		Int B delivered by one speech pathologist				a day 4 days a week	daily homework during treatment Int A & B on completion of 4 week treatment asked to practice daily, 5-10 mins, 3-5 days week for 6 months No description of whether practice was recorded and this was not reported
Xu 2010	61 randomised Int A 30 none lost Int B (usual care) 31 none lost	Int A all completed Int B all completed	Int A Traditional Chinese medicine specialist Int A & B speech therapy by speech therapist	Not described	Between 1-12 months	Int A 9 weeks with one week of no treatment at week 5 Int B 9 weeks	Int A 30 mins, 5 times a week Int A & B 30 mins, 5 times a week	None

APPENDICES

Appendix 1. Cochrane Central Register of Controlled Trials (CENTRAL) search strategy

Cochrane Library databases (CDSR, DARE, CENTRAL, HTA) up to May 2016

1. MeSH descriptor: [Cerebrovascular Disorders] this term only
2. MeSH descriptor: [Basal Ganglia Cerebrovascular Disease] explode all trees
3. MeSH descriptor: [Brain Ischemia] explode all trees
4. MeSH descriptor: [Carotid Artery Diseases] explode all trees
5. MeSH descriptor: [Cerebrovascular Trauma] explode all trees
6. MeSH descriptor: [Intracranial Arteriovenous Malformations] explode all trees
7. MeSH descriptor: [Intracranial Arterial Diseases] explode all trees
8. MeSH descriptor: [Intracranial Embolism and Thrombosis] explode all trees

9. MeSH descriptor: [Intracranial Hemorrhages] explode all trees
10. MeSH descriptor: [Stroke] this term only
11. MeSH descriptor: [Brain Infarction] explode all trees
12. MeSH descriptor: [Stroke, Lacunar] this term only
13. MeSH descriptor: [Vasospasm, Intracranial] this term only
14. MeSH descriptor: [Vertebral Artery Dissection] this term only
15. MeSH descriptor: [Hypoxia, Brain] explode all trees
16. stroke* or "post stroke" or poststroke or post-stroke or apoplex* or cerebrovasc* or CVA or SAH or "cerebral vasc*" (Word variations have been searched)
17. (brain or cerebr* or cerebell* or vertebrobasil* or hemispher* or intracran* or intracerebral or infratentorial or supratentorial or "middle cerebr*" or mca* or "anterior circulaion" or "basilar artery" or "vertebral artery") and (haemi* or ischemi* or thrombos* or thromboem* or emboli* or occlus* or hypoxi*) (Word variations have been searched)
18. (brain* or cerebr* or cerebell* or intracerebral or intracran* or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or "basal gangli*" or putaminal or putamen or "posterior fossa" or hemisphere* or subarachnoid) and (haemorrhag* or hemorrhag* or haematoma* or bleed*) (Word variations have been searched)
19. MeSH descriptor: [Hemiplegia] explode all trees
20. MeSH descriptor: [Paresis] explode all trees
21. MeSH descriptor: [Aphasia] explode all trees
22. MeSH descriptor: [Gait Disorders, Neurologic] explode all trees
23. (hemipar* or hemipleg* or paresis or paretic or aphasi* or dysphasi*) (Word variations have been searched)
24. MeSH descriptor: [Brain Damage, Chronic] explode all trees
25. MeSH descriptor: [Brain Injuries] this term only
26. MeSH descriptor: [Brain Concussion] explode all trees
27. MeSH descriptor: [Brain Hemorrhage, Traumatic] explode all trees
28. MeSH descriptor: [Brain Injury, Chronic] this term only
29. MeSH descriptor: [Diffuse Axonal Injury] this term only
30. MeSH descriptor: [Craniocerebral Trauma] this term only
31. MeSH descriptor: [Head Injuries, Closed] explode all trees
32. MeSH descriptor: [Intracranial Hemorrhage, Traumatic] explode all trees
33. MeSH descriptor: [Brain Abscess] explode all trees
34. MeSH descriptor: [Central Nervous System Infections] explode all trees
35. MeSH descriptor: [Encephalitis] explode all trees
36. MeSH descriptor: [Meningitis] explode all trees
37. (encephalitis or meningitis or "head injur*") (Word variations have been searched)
38. MeSH descriptor: [Brain Neoplasms] explode all trees
39. (brain or cerebr*) and (injur* or hypoxi* or damage* or concussion or trauma* or neoplasm* or lesion* or tumor* or tumour* or cancer* or infection) (Word variations have been searched)
40.{or #1-#39}
41. MeSH descriptor: [Dysarthria] this term only
42. MeSH descriptor: [Articulation Disorders] this term only
43. MeSH descriptor: [Speech Articulation Tests] this term only
44. MeSH descriptor: [Speech Disorders] this term only
45. MeSH descriptor: [Voice Disorders] this term only
46. MeSH descriptor: [Aphonia] this term only
47. MeSH descriptor: [Dysphonia] this term only
48. MeSH descriptor: [Communication Disorders] this term only
49. (dysarth* or dysphon* or anarth* or dyspros* or aphon* or dysfluen* or stutter* or stammer*) (Word variations have been searched)
50. (speech or articul* or disarticul* or phonat* or phonolog* or voice or vocal or prosod* or intonat* or respirat* or communicat* or fluen*) and (disorder* or impair* or problem* or difficult*) (Word variations have been searched)
51. speech and (slow* or weak* or imprecis* or intelligibil* or unintelligibil* or accuracy or fatigue) (Word variations have been searched)
52. {or #41-51}
53. MeSH descriptor: [Mouth] explode all trees
54. MeSH descriptor: [Larynx] explode all trees

55. MeSH descriptor: [Laryngeal Muscles] explode all trees
56. MeSH descriptor: [Pharynx] explode all trees
57. MeSH descriptor: [Pharyngeal Muscles] explode all trees
58. MeSH descriptor: [Facial Muscles] this term only
59. MeSH descriptor: [Palatal Muscles] this term only
60. (mouth or tongue or lingual or palat* or laryn* or pharyn* or orofacial or oro-facial or "face musc*" or facial musc*) (Word variations have been searched)
61. {or #53-#60}
62. MeSH descriptor: [Movement Disorders] this term only
63. MeSH descriptor: [Ataxia] this term only
64. MeSH descriptor: [Dystonia] this term only
65. MeSH descriptor: [Dystonic Disorders] this term only
66. MeSH descriptor: [Hyperkinesis] this term only
67. MeSH descriptor: [Hypokinesia] explode all trees
68. MeSH descriptor: [Muscle Hypertonia] this term only
69. MeSH descriptor: [Muscle Hypotonia] this term only
70. MeSH descriptor: [Muscle Weakness] this term only
71. MeSH descriptor: [Muscular Diseases] this term only
72. MeSH descriptor: [Muscle Spasticity] this term only
73.(atax* or dyston* or hyperkin* or hypokin* or hypoton* or hyper[illegible]* or flaccid* or spastic*) (Word variations have been searched)
74. {or #62-#73}
75. #61 and #74

Appendix 2. MEDLINE (PubMed) search strategy

MEDLINE (PubMed) from 1946 to May 2016

1. Search ((("Cerebrovascular Disorders"[Mesh:noexp]) OR "Basal Ganglia Cerebrovascular Disease"[Mesh]) OR "Brain Ischemia"[Mesh]) OR "Carotid Artery Diseases"[Mesh]) OR "Cerebrovascular Trauma"[Mesh]) OR "Intracranial Arteriovenous Malformations"[Mesh]) OR "Intracranial Arterial Diseases"[Mesh]) OR "Intracranial Embolism and Thrombosis"[Mesh]) OR "Intracranial Hemorrhages"[Mesh]) OR "Stroke"[Mesh:noexp]) OR "Brain Infarction"[Mesh]) OR "Stroke, Lacunar"[Mesh:noexp]) OR "Vasospasm, Intracranial"[Mesh:noexp]) OR "Vertebral Artery Dissection"[Mesh:noexp]) OR "Hypoxia, Brain"[Mesh])
2. Search (stroke*[Text Word] OR "acute stroke"[Text Word] OR poststroke[Text Word] OR post-stroke[Text Word] OR apoplex*[Text Word] OR cerebrovasc*[Text Word] OR CVA[Text Word] OR SAH[Text Word] OR cerebral vasc*[Text Word])
3. Search ((brain[Text Word] OR cerebr*[Text Word] OR cerebell*[Text Word] OR vertebrobasil*[Text Word] OR hemispher*[Text Word] OR intracran*[Text Word] OR intracerebral[Text Word] OR infratentorial[Text Word] OR supratentorial[Text Word] OR middle cerebr*[Text Word] OR mca[Text Word] OR anterior circulation[Text Word] OR basilar artery[Text Word] OR vertebral artery[Text Word])) AND (Ischemi*[Text Word] OR infarct*[Text Word] OR thrombos*[Text Word] OR thromboem*[Text Word] OR emboli*[Text Word] OR occlus*[Text Word] OR hypoxi*[Text Word]))
4. Search (((Brain*[Text Word] OR cerebr*[Text Word] OR cerebell*[Text Word] OR intracerebral[Text Word] OR intracran*[Text Word] OR parenchymal[Text Word] OR intraparenchymal[Text Word] OR intraventricular[Text Word] OR infratentorial[Text Word] OR supratentorial[Text Word] OR basal gangli*[Text Word] OR putaminal[Text Word] OR putamen[Text Word] OR posterior fossa[Text Word] OR hemisphere*[Text Word] OR subarachnoid[Text Word])) AND (haemorrhag*[Text Word] OR hemorrhag*[Text Word] OR haematoma*[Text Word] OR hematoma*[Text Word] OR bleed*[Text Word]))
5. Search ((Hemiplegia"[Mesh]) OR "Paresis"[Mesh]) OR "Aphasia"[Mesh]) OR "Gait Disorders, Neurologic"[Mesh])
6. Search (Hemipar*[Text Word] OR hemipleg*[Text Word] OR paresis[Text Word] OR paretic[Text Word] OR aphasi*[Text Word] OR dysphasi*[Text Word])
7. Search (("Brain Damage, Chronic"[Mesh]) OR "Brain Injuries"[Mesh:noexp]) OR "Brain Concussion"[Mesh]) OR "Brain Hemorrhage, Traumatic"[Mesh]) OR "Brain Injury, Chronic"[Mesh:noexp]) OR "Diffuse Axonal Injury"[Mesh:noexp])
8. Search (("Craniocerebral Trauma"[Mesh:noexp]) OR "Head Injuries, Closed"[Mesh]) OR "Intracranial Hemorrhage, Traumatic"[Mesh])
9. Search (("Brain Abscess"[Mesh]) OR "Central Nervous System Infections"[Mesh]) OR "Encephalitis"[Mesh]) OR "Meningitis"[Mesh])

10. Search (encephalitis[Text Word] OR meningitis[Text Word] OR head injur*[Text Word])
11. Search "Brain Neoplasms"[Mesh]
12. Search (((brain[Text Word] OR cerebr*[Text Word])) AND (injur*[Text Word] OR hypoxi*[Text Word] OR damage*[Text Word] OR concussion[Text Word] OR trauma*[Text Word] OR neoplasm*[Text Word] OR lesion*[Text Word] OR tumor*[Text Word] OR tumour*[Text Word] OR cancer*[Text Word] OR infection[Text Word]))
13. Search (#1 OR #2 OR #3 OR #4 OR #5 OR #6 OR #7 OR #8 OR #9 OR #10 OR #11 OR #12)
14. Search (("Dysarthria"[Mesh:noexp]) OR "Articulation Disorders"[Mesh:noexp]) OR "Speech Articulation Tests"[Mesh:noexp])
15. Search ("Speech Disorders"[Mesh:noexp]) OR "Voice Disorders"[Mesh:noexp]) OR "Aphonia"[Mesh:noexp]) OR "Dysphonia"[Mesh:noexp]) OR "Communication Disorders"[Mesh:noexp])
16. Search (dysarth*[Text Word] OR dysphon*[Text Word] OR anarth*[Text Word] OR dysprosod*[Text Word] OR aphon*[Text Word] OR dysfluen*[Text Word] OR stutter*[Text Word] OR stammer*[Text Word])
17. Search (((speech[Text Word] OR articul*[Text Word] OR disarticul*[Text Word] OR phonat*[Text Word] OR phonolog*[Text Word] OR voice[Text Word] OR vocal[Text Word] OR prosod*[Text Word] OR intonat*[Text Word] OR respirat*[Text Word] OR communicat*[Text Word] OR fluen*[Text Word])) AND (disorder*[Text Word] OR impair*[Text Word] OR problem*[Text Word] OR difficult*[Text Word]))
18. Search (speech[Text Word]) AND (slow*[Text Word] OR weak*[Text Word] OR imprecis*[Text Word] OR intelligibil*[Text Word] OR unintelligibil*[Text Word] OR accuracy[Text Word] OR fatigue[Text Word])
19. Search ("Mouth"[Mesh]) OR "Larynx"[Mesh]) OR "Laryngeal Muscles"[Mesh]) OR "Pharynx"[Mesh:noexp]) OR "Pharyngeal Muscles"[Mesh]) OR "Facial Muscles"[Mesh:noexp]) OR "Palatal Muscles"[Mesh:noexp])
20. Search (mouth[Text Word] OR tongue[Text Word] OR lingual[Text Word] OR palat*[Text Word] OR laryn*[Text Word] OR pharyn*[Text Word] OR orofacial[Text Word] OR oro-facial[Text Word] OR face musc*[Text Word] OR facial musc*[Text Word])
21. Search (#19 OR #20)
22. Search ("Movement Disorders"[Mesh:noexp]) OR "Ataxia"[Mesh:noexp]) OR "Dystonia"[Mesh:noexp]) OR "Dystonic Disorders"[Mesh:noexp]) OR "Hyperkinesis"[Mesh:noexp]) OR "Hypokinesia"[Mesh:noexp]) OR "Muscle Hypertonia"[Mesh:noexp]) OR "Muscle Hypertonia"[Mesh]) OR "Muscle Hypotonia"[Mesh:noexp]) OR "Muscle Weakness"[Mesh:noexp]) OR "Muscular Diseases"[Mesh:noexp]) OR "Muscle Spasticity"[Mesh:noexp])
23. Search (atax*[Text Word] OR dyston*[Text Word] OR hyperkin*[Text Word] OR hypokin*[Text Word] OR hypoton*[Text Word] OR hyperton*[Text Word] OR flaccid*[Text Word] OR spastic*[Text Word])
24. Search (#22 OR #23)
25. Search (#21 AND #24)
26. Search (#14 OR #15 OR #16 OR #17 OR #18 OR #25)
27. Search "Randomized Controlled Trials as Topic"[Mesh:noexp]
28. Search "Random Allocation"[Mesh:noexp]
29. Search "Controlled Clinical Trials as Topic"[Mesh:noexp]
30. Search "Control Groups"[Mesh:noexp]
31. Search ("Clinical Trials as Topic"[Mesh:noexp]) OR "Clinical Trials, Phase I as Topic"[Mesh:noexp]) OR "Clinical Trials, Phase II as Topic"[Mesh:noexp]) OR "Clinical Trials, Phase III as Topic"[Mesh:noexp]) OR "Clinical Trials, Phase IV as Topic"[Mesh:noexp])
32. Search "Double-Blind Method"[Mesh:noexp]
33. Search "Single-Blind Method"[Mesh:noexp]
34. Search "Placebos"[Mesh:noexp]
35. Search "Placebo Effect"[Mesh:noexp]
36. Search "Cross-Over Studies"[Mesh:noexp]
37. Search randomized controlled trial[Publication Type]
38. Search controlled clinical trial[Publication Type]
39. Search clinical trial[Publication Type] OR clinical trial, phase i[Publication Type] OR clinical trial, phase ii[Publication Type] OR clinical trial, phase iii[Publication Type] OR clinical trial, phase iv[Publication Type])
40. Search (random*[Text Word] OR RCT[Text Word] OR RCTs[Text Word])
41. Search (controlled[Text Word]) AND (trial*[Text Word] OR stud*[Text Word])
42. Search (clinical*[Text Word] AND trial*[Text Word])
43. Search (control[Text Word] OR treatment[Text Word] OR experiment*[Text Word] OR intervention[Text Word])) AND (group*[Text Word] OR subject*[Text Word] OR patient*[Text Word])
44. Search (quasi-random*[Text Word] OR quasi random*[Text Word] OR pseudo-random*[Text Word] OR pseudo random*[Text Word])

45. Search (control[Text Word] OR experiment*[Text Word] OR conservative[Text Word])) AND (treatment[Text Word] OR therapy[Text Word] OR procedure[Text Word] OR manage*[Text Word])
46. Search (singl*[Text Word] OR doubl*[Text Word] OR tripl*[Text Word] OR trebl*[Text Word])) AND (blind*[Text Word] OR mask*[Text Word])
47. Search (cross-over[Text Word]) OR cross over[Text Word]) OR crossover[Text Word])
48. Search (placebo*[Text Word] OR sham[Text Word])
49. Search trial[Title]
50. Search (assign*[Text Word] OR allocat*[Text Word])
51. Search controls[Text Word]
52. Search (#27 OR #28 OR #29 OR #30 OR #31 OR #32 OR #33 OR #34 OR #35 OR #36 OR #37 OR #38 OR #39 OR #40 OR #41 OR #42 OR #43 OR #44 OR #45 OR #46 OR #47 OR #48 OR #49 OR #50 OR #51)
53. Search (#13 AND #26 AND #52)
54. Search ("Animals"[Mesh]) NOT "Humans"[Mesh:noexp])
55. Search (#53 NOT #54)

Appendix 3. EMBASE (Ovid) search strategy

EMBASE (Ovid) from 1974 to May 2016

1. CEREBROVASCULAR DISEASE/ or exp BASAL GANGLION DISEASE/ or exp BASAL GANGLION HEMORRHAGE/ or exp BRAIN ISCHEMIA/ or exp CAROTID ARTERY DISEASE/ or exp CEREBROVASCULAR ACCIDENT/ or exp CEREBRAL ARTERY DISEASE/ or exp BRAIN ARTERIOVENOUS MALFORMATION/ or exp BRAIN EMBOLISM/ or exp OCCLUSIVE CEREBROVASCULAR DISEASE/ or exp BRAIN HEMORRHAGE/ or exp BRAIN INFARCTION/ or LACUNAR STROKE/ or STROKE/ or BRAIN VASOSPASM/ or ARTERY DISSECTION/ or exp BRAIN HYPOXIA/
2. (stroke$ or post stroke or poststroke or post-stroke or apoplex$ or cerebral vasc$ or cerebrovasc$ or cva or SAH).ti,ab
3. ((brain or cerebr$ or cerebell$ or vertebrobasil$ or hemisphere or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebr$ or mca$ or anterior circulation or basilar artery or vertebral artery) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).ti,ab.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h?ematoma$ or bleed$)).ti,ab
5. exp HEMIPLEGIA/ or exp PARESIS/ or exp APHASIA/ or exp NEUROLOGIC GAIT DISORDER/
6. (hemipar$ or hemipleg$ or paresis or paretic or aphasi$ or dysphasi$).ti,ab
7. exp BRAIN DAMAGE, CHRONIC/ or BRAIN INJURY/ or exp BRAIN CONCUSSION/ or exp BRAIN HAEMORRHAGE, TRAUMATIC/ or BRAIN INJURY, CHRONIC/ or DIFFUSE AXONAL INJURY/
8. HEAD INJURY/ or exp HEAD INJURIES, CLOSED/ or exp INTRACRANIAL HEMORRHAGE, TRAUMATIC/
9. exp BRAIN ABSCESS/ or exp CENTRAL NERVOUS SYSTEM INFECTION/ or exp ENCEPHALITIS/ or exp MENINGITIS
10. (encephalitis or meningitis or head injur$).ti,ab.
11. exp BRAIN TUMOR/
12. ((brain or cerebr$) adj5 injur$ or hypoxi$ or damage$ or concussion or trauma$ or neoplasm$ or lesion$ or tumor$ or tumour$ or cancer$ or infection$)).ti,ab.
13. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12
14. DYSARTHRIA/ or SPEECH SOUND DISORDER/ or SPEECH ARTICULATION TESTS/
15. SPEECH DISORDER/ or VOICE DISORDER/ or APHONIA/ or DYSPHONIA/ or COMMUNICATION DISORDER/
16. (dysarth$ or dysphon$ or anarth$ or dyspros$ or aphon$ or dysfluen$ or stutter$ or stammer$).ti,ab
17. ((speech or articul$ or disarticul$ or phonat$ or phonolog$ or voice or vocal or prosod$ or intonat$ or respirat$ or communicat$ or fluen$) adj5 (disorder$ or impair$ or problem$ or difficult$)).ti,ab
18. (speech adj5 (slow$ or weak$ or imprecis$ or intelligibil$ or unintelligibil$ or accuracy or fatigue)).ti,ab
19. exp MOUTH/ or exp LARYNX/ or exp LARYNX MUSCLE/ or PHARYNX/ or exp PHARYNGEAL MUSCLE/ or FACE MUSCLE/ or PALATE/
20. (mouth or tongue or lingual or palat$ or laryn$ or pharyn$ or orofacial or oro-facial or face musc$ or facial musc$).ti,ab
21. 19 or 20

22. MOTOR DYSFUNCTION/ or ATAXIA/ or DYSTONIC DISORDER/ or HYPERKINESIA/ or HYPOKINESIA/ or MUSCLE HYPOTONIA/ or exp MUSCLE HYPOTONIA/ or MUSCLE WEAKNESS/ or MUSCLE DISEASE/ or SPASTICITY/
23. (atax$ or dyston$ or hyperkin$ or hypokin$ or hypoton$ or hyperton$ or flaccid$ or spastic$).ti,ab
24. 22 or 23
25. 21 and 24
26. 14 or 15 or 16 or 17 or 18 or 25
27. "RANDOMIZED CONTROLLED TRIAL (TOPIC)"/
28. RANDOMIZATION/
29. "CONTROLLED CLINICAL TRIAL (TOPIC)"/
30. CONTROL GROUP/
31. "CLINICAL TRIAL (TOPIC)"/ or "PHASE 1 CLINICAL TRIAL (TOPIC)"/ or "PHASE 2 CLINICAL TRIAL (TOPIC)"/ or "PHASE 3 CLINICAL TRIAL (TOPIC)"/ or "PHASE 4 CLINICAL TRIAL (TOPIC)"/
32. DOUBLE BLIND PROCEDURE/
33. SINGLE BLIND PROCEDURE/
34. PLACEBO/
35. PLACEBO EFFECT/
36. CROSSOVER PROCEDURE/
37. RANDOMIZED CONTROLLED TRIAL/
38. CLINICAL TRIAL/
39. PHASE 1 CLINICAL TRIAL/ or PHASE 2 CLINICAL TRIAL/ or PHASE 3 CLINICAL TRIAL/ or PHASE 4 CLINICAL TRIAL/
40. (random$ or RCT or RCTs).ti,ab
41. (controlled adj5 (trial$ or stud$)).ti,ab
42. (clinical$ adj5 trial$).ti,ab.
43. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).ti,ab
44. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).ti,ab
45. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).ti,ab.
46. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).ti,ab
47. (cross-over or cross over or crossover).ti,ab
48. (placebo$ or sham).ti,ab.
49. trial.ti
50. (assign$ or allocat$).ti,ab
51. controls.ti,ab.
52. 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50 or 51
53. 13 and 26 and 52
54. exp ANIMALS/ not HUMANS/
55. 53 not 54

Appendix 4. CINAHL (NICE Evidence Services Portal HDAS) search strategy

CINAHL (Ovid) from 1937 to May 2016

1. CEREBROVASCULAR DISORDERS/ OR exp BASAL GANGLIA CEREBROVASCULAR DISEASE/ OR exp HYPOXIA-BRAIN,ISCHEMIA/ OR exp CAROTID ARTERY DISEASES/ OR exp CEREBROVASCULAR CIRCULATION/ OR exp INTRACRANIAL ARTERIAL DISEASES/ OR exp ARTERIOVENOUS MALFORMATIONS/ OR exp INTRACRANIAL EMBOLISM AND THROMBOSIS/ OR exp INTRACRANIAL HEMORRHAGE/ OR STROKE/ OR STROKE,LACUNAR/ OR CEREBRAL VASOSPASM/ OR VERTEBRAL ARTERY DISSECTIONS/ OR exp HYPOXIA,BRAIN
2. (stroke* OR "post stroke" OR poststroke OR post-stroke OR apoplex* OR "cerebral vasc*" OR cerebrovasc* OR cva OR SAH OR "brain infarction" OR "cerebrovascular trauma").ti,ab
3. ((brain OR cerebr* OR cerebell* OR vertebrobasil* OR hemispher* OR intracran* OR intracerebral OR infratentorial OR supratentorial OR "middle cerebr*" OR mca* OR "anterior circulation" OR "basilar artery" OR "vertebral artery") adj5 (ischemi* OR ischaemi* OR infarct* OR thrombo* OR emboli* OR occlus* OR hypoxi*)).ti,ab;

4. ((brain* OR cerebr* OR cerebell* OR intracerebral OR intracran* OR parenchymal OR intraparenchymal OR intraventricular OR infratentorial OR supratentorial OR "basal gangli*" OR putaminal OR putamen OR "posterior fossa" OR hemispher* OR subarachnoid) adj5 (hemorrhag* OR haemorrhag* OR hematoma* OR haematoma* OR bleed*)).ti,ab;
5. exp HEMIPLEGIA/ OR exp PARALYSIS/ OR exp APHASIA/ OR exp GAIT DISORDERS,NEUROLOGIC/;
6. (hemipar* OR hemipleg* OR paresis OR paretic OR aphasi* OR dysphasi*).ti,ab;
7. exp BRAIN DAMAGE,CHRONIC/ OR BRAIN INJURIES/ OR exp BRAIN CONCUSSION/ OR exp INTRACRANIAL HEMORRHAGE/
8. ("chronic brain injury" OR "diffuse axonal injury" OR "craniocerebral trauma" OR "closed head injur*" OR "intracranial hemorrhag*").ti,ab
9. exp BRAIN ABSCESS/ OR exp CENTRAL NERVOUS SYSTEM INFECTIONS/ OR exp ENCEPHALITIS/ OR exp MENINGITIS/
10. (encephalitis OR meningitis OR "head injur*" OR "traumatic brain hemorrhag*" OR "chronic brain injury" OR "diffuse axonal injury" OR "craniocerebral trauma" OR "closed head injur*" OR "intracranial hemorrhag*").ti,ab
11. exp BRAIN NEOPLASMS/
12. ((brain OR cerebr*) adj5 (injur* OR hypoxi* OR damage* OR concussion OR trauma OR neoplas* OR lesion* OR tumor* OR tumour* OR cancer* OR infection*)).ti,ab
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12
14. DYSARTHRIA/ OR ARTICULATION DISORDERS/ OR SPEECH ARTICULATION TESTS/
15. SPEECH DISORDERS/ OR VOICE DISORDERS/ OR APHONIA/ OR DYSPHONIA,SPASMODIC/ OR DYSPHONIA,MUSCLE TENSION/ OR COMMUNICATIVE DISORDERS/
16. (dysarth* OR dysphon* OR anarth* OR dyspros* OR aphon* OR dysfluen* OR stutter* OR stammer*).ti,ab
17. ((speech OR articul* OR disarticul* OR phonat* OR phonolog* OR voice OR vocal OR prosod* OR intonat* OR respirat* OR communicat* OR fluen*) adj5 (disorder* OR impair* OR problem* OR difficult*))
18. (speech adj5 (slow* OR weak* OR imprecis* OR intelligibil* OR unintelligibil* OR accuracy OR fatigue)).ti,ab
19. exp MOUTH/ OR exp LARYNX/ OR exp LARYNGEAL MUSCLES/ OR PHARYNX/ OR exp PHARYNGEAL MUSCLES/ OR FACIAL MUSCLES/ OR PALATAL MUSCLES/
20. (mouth OR tongue OR lingual OR palat* OR laryn* OR pharyn* OR orofacial OR oro-facial OR "face musc*" OR "facial musc*").ti,ab
21. 19 OR 20
22. MOVEMENT DISORDERS/ OR ATAXIA/ OR DYSTONIA/ OR DYSTONIC DISORDERS/ OR HYPERKINESIS/ OR HYPOKINESIA/ OR MUSCLE HYPOTONIA/ OR exp MUSCLE HYPERTONIA/ OR MUSCLE WEAKNESS/ OR MUSCULAR DISEASES/ OR MUSCLE SPASTICITY/
23. (atax* OR dyston* OR hyperkin* OR hypokin* OR hypoton* OR hyperton* OR flaccid* OR spastic*).ti,ab
24. 22 OR 23
25. 21 AND 24
26. 14 OR 15 OR 16 OR 17 OR 18 OR 25
27. RANDOMIZED CONTROLLED TRIALS/
28. RANDOM ASSIGNMENT/
29. CLINICAL TRIALS/
30. CONTROL GROUP/
31. ("clinical trials" OR "clinical trials,phase i" OR "clinical trials,phase ii" OR "clinical trials,phase iii" OR "clinical trials,phase iv").ti,ab
32. DOUBLE-BLIND STUDIES/
33. SINGLE-BLIND STUDIES/
34. PLACEBOS/
35. PLACEBO EFFECT/
36. CROSSOVER DESIGN/
37. "randomized controlled trial".pt
38. "controlled clinical trial".pt
39. ("clinical trial" OR "clinical trial phase i" OR "clinical trial phase ii" OR "clinical trial phase iii" OR "clinical trial phase iv").pt
40. (random* OR RCT OR RCTs).ti,ab
41. (controlled adj5 (trial* OR stud*)).ti,ab
42. (clinical* adj5 trial*).ti,ab

43. ((control OR treatment OR experiment* OR intervention) adj5 (group* OR subject* OR patient*)).ti,ab
44. (quasi-random* OR "quasi random*" OR pseudo-random* OR "pseudo random*").ti,ab
45. ((control OR experiment* OR conservative) adj5 (treatment OR therapy OR procedure OR manage*)).ti,ab
46. ((singl* OR doubl* OR tripl* OR trebl*) adj5 (blind* OR mask*)).ti,ab
47. (cross-over OR "cross over" OR crossover).ti,ab
48. (placebo* OR sham).ti,ab
49. trial.ti
50. (assign* OR allocat*).ti,ab
51. controls.ti,ab
52. 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46 OR 47 OR 48 OR 49 OR 50 OR 51
53. 13 AND 26 AND 52
54. exp ANIMALS/ NOT HUMAN/
55. 53 NOT 54

Appendix 5. PsycINFO search strategy

PsycINFO (Ovid) from 1800 to September 2016

1. cerebrovascular disorders/ or cerebral hemorrhage/ or exp cerebral ischemia/ or cerebral small vessel disease/ or cerebrovascular accidents/ or subarachnoid hemorrhage/
2. (stroke$ or poststroke or apoplex$ or cerebral vasc$ or brain vasc$ or cerebrovasc$ or cva$ or SAH).tw.
3. ((brain or cerebr$ or cerebell$ or vertebrobasil$ or hemispher$ or intracran$ or intracerebral or infratentorial or supratentorial or middle cerebral artery or MCA$ or anterior circulation or posterior circulation or basilar artery or vertebral artery or space-occupying) adj5 (isch?emi$ or infarct$ or thrombo$ or emboli$ or occlus$ or hypoxi$)).tw.
4. ((brain$ or cerebr$ or cerebell$ or intracerebral or intracran$ or parenchymal or intraparenchymal or intraventricular or infratentorial or supratentorial or basal gangli$ or putaminal or putamen or posterior fossa or hemispher$ or subarachnoid) adj5 (h?emorrhag$ or h?ematoma$ or bleed$)).tw.
5. hemiparesis/ or hemiplegia/
6. (hemipleg$ or hemipar$ or paresis or paretic).tw.
7. head injuries/ or exp brain concussion/ or brain damage/ or exp traumatic brain injury/
8. ((brain or cerebr$) adj5 (injur$ or hypoxi$ or damage$ or concussion or trauma$ or neoplasm$ or lesion$ or tumor$ or tumour$ or cancer$ or infection$)).tw.
9. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10. dysarthria/ or articulation disorders/
11. dysphonia/ or speech disorders/
12. (dysarth$ or dyphon$ or anarth$ or dyspros$ or aphon$ or dysfluen$ or stutter$ or stammer$).tw.
13. ((speech or articul$ or inarticul$ or phonat$ or phonolog$ or voice or vocal or prosod$ or intonat$ or respirat$ or communicat$ or fluen$) adj5 (disorder$ or impair$ or problem$ or difficult$)).tw.
14. (speech adj5 (slow$ or weak$ or imprecis$ or intelligibil$ or unintelligibil$ or accuracy or fatigue)).tw.
15. "mouth (anatomy)"/ or exp tongue/ or larynx/ or pharynx/ or vocal cords/ or facial muscles/
16. (mouth or tongue or lingual or palat$ or laryn$ or pharyn$ or orofacial or oro-facial or face musc$ or facial musc$).tw.
17. 14 or 15 or 16
18. muscular disorders/ or movement disorders/ or ataxia/ or bradykinesia/ or dyskinesia/ or hyperkinesis/ or neuromuscular disorders/ or spasms/ or muscle spasms/
19. (atax$ or dyskin$ or hyperkin$ or hypokin$ or hypoton$ or hyperton$ or flaccid$ or spastic$).tw.
20. 18 or 19
21. 17 and 20
22. 10 or 11 or 12 or 13 or 14 or 21
23. clinical trials/ or treatment effectiveness evaluation/ or placebo/
24. (random$ or RCT or RCTs).tw.
25. (controlled adj5 (trial$ or stud$)).tw.
26. (clinical$ adj5 trial$).tw.

27. ((control or treatment or experiment$ or intervention) adj5 (group$ or subject$ or patient$)).tw.
28. (quasi-random$ or quasi random$ or pseudo-random$ or pseudo random$).tw.
29. ((control or experiment$ or conservative) adj5 (treatment or therapy or procedure or manage$)).tw.
30. ((singl$ or doubl$ or tripl$ or trebl$) adj5 (blind$ or mask$)).tw.
31. (cross-over or cross over or crossover).tw.
32. (placebo$ or sham).tw.
33. trial.ti.
34. (assign$ or allocat$).tw.
35. controls.tw.
36. 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35
37. 9 and 22 and 36

Appendix 6. Linguistics and Language Behavior Abstracts (LLBA) search strategy

LLBA (ProQuest) 1976 to November 2016

(((dysarth* OR dysphon* OR anarth* OR dyspros* OR aphon* OR dyston*) OR ((speech OR articulat* OR voice OR vocal OR communicat*) AND (disorder* OR impair* OR problem* OR difficult*)) OR ((phonat* OR prosod* OR intonat* OR respirat*) AND (disorder* OR impair* OR problem* OR difficult*)) OR SU("Articulation Disorders" OR "Dysarthria"))) AND (SU("Brain Damage" OR "Stroke") OR (stroke* OR "post stroke" OR poststroke OR post-stroke OR apoplex* OR cerebrovasc* OR CVA OR SAH OR "cerebral vasc*"))

WHAT'S NEW

Last assessed as up-to-date: 6 May 2016.

Date	Event	Description
12 May 2016	New search has been performed	The review title, and scope of searches have been updated since the last review. The previous review found no studies suitable for inclusion. Five new studies (234 participants) have been included in the review. This review includes risk of bias assessment, grading of the quality of evidence and a summary of findings table
12 May 2016	New citation required and conclusions have changed	This updated review has found that while the evidence was not robust enough to indicate whether one treatment was better than another the conclusion of this updated review describes future research directions in more detail

HISTORY

Protocol first published: Issue 1, 2000

Review first published: Issue 2, 2001

Date	Event	Description
1 April 2015	Amended	Amendments to update the protocol agreed with the Cochrane Stroke Group Editorial Board
3 December 2014	Amended	New first author and co-author team with previous lead author remaining involved
2 October 2008	Amended	Converted to new review format.
4 February 2005	New search has been performed	All literature searches for this review have been updated. No new trials for inclusion have been uncovered by these searches

CONTRIBUTIONS OF AUTHORS

Claire Mitchell initiated and designed the review, conducted the search, screened and retrieved references, contacted relevant authors, obtained translations for non-English publications, requested ongoing and unpublished study information, extracted data from included trials, evaluated methodological quality, entered and analysed the data, interpreted the findings and wrote the review. Audrey Bowen designed the review, screened references for inclusion, extracted data from included trials, evaluated methodological quality, analysed the data, interpreted the findings and contributed to the writing of the review. Sarah Tyson supported decision-making for inclusion, contributed to the writing of the review and commented on review drafts. Zoe Butterfint commented on the final versions of the updated review. Paul Conroy designed the review, screened references for inclusion, extracted data from included trials, evaluated methodological quality, analysed the data, interpreted the findings and contributed to the writing of the review.

DECLARATIONS OF INTEREST

Claire Mitchell is a speech and language therapist and is funded by a National Institute for Health Research Doctoral Research Fellowship (DRF-2014-07-043) and is registered with the Health and Care Professions Council, UK. Audrey Bowen's salary is part funded by Stroke Association and partly by the National Institute for Health Research Collaboration for Leadership in Applied Health Research and Care (NIHR CLAHRC) Greater Manchester. Audrey Bowen has been involved in a study included in this review Bowen 2012. She did not contribute to the assessment or interpretation of this study. Sarah Tyson, none known. Zoe Butterfint, none known. Paul Conroy is a speech and language therapist, member of the Royal College of Speech and Language Therapists, and is registered with the Health and Care Professions Council, UK.

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Search terms and searching
- New Source of support, Other.

External sources

- National Institute for Health Research, UK.

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DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The title of this review has been changed to reflect the broader scope of the search which is intended to have a more global reach. The search terms for this review now include interventions carried out by any health professional, the patient themselves or a trained individual (whether voluntary, employed or family member) or any other possible approaches to delivery. This review has considered any type of intervention for acquired dysarthria including behavioural or psychological approaches, use of devices and medication with the exception of surgical intervention. This review was also designed to reflect the International levels of functioning including impairment, activity and participation level effects (WHO 2007). Examination of risk of bias was included in this review in accordance with recent developments from the Cochrane Collaboration (Higgins 2011). This review includes a summary of findings table which includes the five GRADE considerations to assess the quality of the body of evidence of the studies included in the meta-analysis using GRADEproGDT software (GRADEproGDT 2015). The primary outcome in the protocol was to examine long term, persistent effectiveness between 3-9 months post-intervention but during the review process we found this time criteria was too restrictive. Following discussion between the authors the timing of this were relaxed to include Mackenzie 2014, which was felt to be the most appropriate way forward but it must be noted this is a change from the protocol.