Cochrane
Library

Cochrane Database of Systematic Reviews

Intervention for dysarthria associated with acquired brain injury in children and adolescents (Review)

Morgan AT, Vogel AP

Morgan AT, Vogel AP.

Intervention for dysarthria associated with acquired brain injury in children and adolescents.

Cochrane Database of Systematic Reviews 2008, Issue 3. Art. No.: CD006279.

DOI: 10.1002/14651858.CD006279.pub2.

www.cochranelibrary.com

TABLE OF CONTENTS

HEADER	1
ABSTRACT	1
PLAIN LANGUAGE SUMMARY	2
BACKGROUND	2
OBJECTIVES	4
METHODS	4
RESULTS	5
DISCUSSION	5
AUTHORS' CONCLUSIONS	7
ACKNOWLEDGEMENTS	8
REFERENCES	8
CHARACTERISTICS OF STUDIES	11
APPENDICES	12
WHAT'S NEW	17
CONTRIBUTIONS OF AUTHORS	17
DECLARATIONS OF INTEREST	18
SOURCES OF SUPPORT	18
DIFFERENCES BETWEEN PROTOCOL AND REVIEW	18
INDEX TERMS	18

[Intervention Review]

Intervention for dysarthria associated with acquired brain injury in children and adolescents

Angela T Morgan¹, Adam P Vogel²

¹Healthy Development [Theme], Language & Literacy, Murdoch Childrens Research Institute, Melbourne, Australia. ²Centre for Neuroscience, The University of Melbourne, Melbourne, Australia

Contact address: Angela T Morgan, Healthy Development [Theme], Language & Literacy, Murdoch Childrens Research Institute, Parkville, Melbourne, Victoria, 3052, Australia. angela.morgan@mcri.edu.au.

Editorial group: Cochrane Developmental, Psychosocial and Learning Problems Group.

Publication status and date: New, published in Issue 1, 2010.

Citation: Morgan AT, Vogel AP. Intervention for dysarthria associated with acquired brain injury in children and adolescents. *Cochrane Database of Systematic Reviews* 2008, Issue 3. Art. No.: CD006279. DOI: 10.1002/14651858.CD006279.pub2.

Copyright © 2010 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.

ABSTRACT

Background

The term 'acquired brain injury' (ABI) incorporates a range of aetiologies including cerebrovascular accident, brain tumour and traumatic brain injury. ABI is a common cause of disability in the paediatric population, and dysarthria is a common and often persistent sequelae associated with ABI in children.

Objectives

To assess the efficacy of intervention delivered by Speech and Language Pathologists/Therapists targeting dysarthric speech in children resulting from acquired brain injury.

Search methods

We searched CENTRAL (Issue 4, 2006), MEDLINE (1966 to 02/2007), CINAHL (1982 to 02/2007), EMBASE (1980 to 02/2007), ERIC (1965 to 02/2007), Linguistics Abstracts Online (1985 to 02/07), PsycINFO (1872 to 02/2007). Additional references were also sought from reference lists studies.

Selection criteria

The review considered randomised controlled trials (RCTs) and quasi-experimental design studies of children aged 3-16 years with acquired dysarthria grouped by aetiology (e.g., brain tumour, traumatic brain injury, cerebrovascular accident).

Data collection and analysis

Each author independently assessed the titles and abstracts for relevance (100% inter-rater reliability) and the full text version of all potentially relevant articles was obtained. No studies met inclusion criteria.

Main results

Of 2091 titles and abstracts identified, full text versions of only three (Morgan 2007; Murdoch 1999; Netsell 2001) were obtained. 2088 were excluded, largely on the basis of not including dysarthria, being diagnostic or descriptive papers, and for concerning adults rather than children. Morgan 2007 and Murdoch 1999 were excluded for not employing RCT or quasi-randomised methodology; Netsell 2001 on the basis of being a theoretical review paper, rather than an intervention study. Five references were identified and obtained from the bibliography of the Murdoch 1999 paper. All were excluded due to including populations without ABI, adults with dysarthria, or inappropriate design. Thus, no studies met inclusion criteria.

Authors' conclusions

The review demonstrates a critical lack of studies, let alone RCTs, addressing treatment efficacy for dysarthria in children with ABI. Possible reasons to explain this lack of data include i) a lack of understanding of the characteristics or natural history of dysarthria associated with this population; ii) the lack of a diagnostic classification system for children precluding the development of well targeted intervention programs; and iii) the heterogeneity of both the aetiologies and resultant possible dysarthria types of paediatric ABI. Efforts should first be directed at modest well-controlled studies to identify likely efficacious treatments that may then be trialed in multi-centre collaborations using quasi-randomised or RCT methodology.

PLAIN LANGUAGE SUMMARY

Controlled studies for treatment of dysarthria associated with acquired brain injury in childhood urgently required

Dysarthria is a disorder of speech production that can make it harder for people to be understood by others. Dysarthria is a common and often chronic outcome associated with brain injury suffered in childhood (also known as paediatric acquired brain injury (ABI)).

This research examines the efficacy of treatment for dysarthria in children following ABI.

Although this research reports that positive gains have been reported from a case-based study of a child with dysarthria following ABI (specifically with traumatic brain injury), there are currently too few studies performed in this area to draw any conclusions about the efficacy of treatment for dysarthria in children and teenagers. This review therefore calls for Speech Language Pathologists/Speech Language Therapists (SLPs/SLTs) working in this area to perform studies of the natural history and treatment efficacy of this group.

BACKGROUND

Description of the condition

The term 'Acquired Brain Injury' (ABI) encompasses a wide range of aetiologies within the paediatric population with neurological injury, including diagnoses of cerebrovascular accident and brain tumour. The largest population however, is commonly children who have sustained a traumatic brain injury such as that incurred in a fall or motor vehicle accident (Parslow 2005). The incidence of paediatric acquired brain injury is significant, with reports of up to two hundred and eighty per 100,000 children being admitted to hospital with traumatic brain injury in the UK alone each year (Hawley 2003).

The high incidence of acquired brain injury in children is of major public concern, as it is the most frequent cause of acquired disability in children, leaving a large proportion of those who survive with multiple long-term impairments (Tennant 1995; Michaud 1993). One chronic impairment commonly associated with ABI is a form of speech disorder called dysarthria (Cahill 2002; Cornwell 2003a; Cornwell 2003b).

Dysarthria is a motor speech disorder that may affect the range, rate, strength and co-ordination of the muscles used for speech.

This problem may affect multiple subsystems required for accurate speech production including: articulation, resonance, prosody, respiration and phonation (Van Mourik 1997). Specific characteristics of dysarthria following ABI may include: imprecise consonant production and vowel distortion, abnormal resonance (hyper, hypo or mixed nasality), monopitch, monoloudness, changes in speaking rate, and poor respiratory support for speech (Cahill 2004; Cahill 2005; Morgan 2007; Murdoch 1999). Dysarthria can significantly affect the intelligibility of speech, resulting in the child with dysarthria often being misunderstood and experiencing communication breakdown. This communication breakdown may have negative affects on a child's education, socialisation, potential for later employment, and hence participation in and contribution to society.

Intelligibility is defined as the degree to which a speaker can be understood by the listener (Yorkston 1996), and ratings of intelligibility therefore tell us how a speech disorder impacts upon the ability of a given person to communicate (DeBodt 2002).

There is debate regarding whether children and adults present with similar features of dysarthria. A review of studies reporting the clinical presentation of childhood acquired dysarthria concluded that there were no definite similarities between adult and paediatric clinical presentations of dysarthria in the literature published between 1980-1997 (Van Mourik 1997). In contrast, others have

reported similar features of dysarthria between children and adults (Cahill 2004). Even if features of the disorder are similar between these populations, it would be anticipated that dysarthria in children is further complicated by a variety of developmental issues. Paediatric dysarthria occurs in a context of brain maturation, rapid physical growth, and cognitive and psychosocial development. In addition, children are still acquiring their sound production system, and the oral musculature and quality of oral movements change during development (Qvarnstrom 1994). Thus the features of childhood dysarthria following brain injury, and the potential benefit of particular speech treatments should not be extrapolated from the adult literature.

Description of the intervention

There is currently a push for evidence-based practice and accountability of practice in regard to all aspects of health treatment. Despite this fact, there is very little evidence base for the treatment of paediatric dysarthria following ABI. Existing techniques are reported for use with the adult population and are largely based on traditional perceptual models of speaker-based treatment techniques including drills to improve stress or intonation based on improving breath capacity or altering breath pattern (Bellaire 1986; Rosenbek 1991; Yorkston 1988; Yorkston 1999), treatment designed to alter rate control (Beukelman 1978; Crow 1989; Helm 1979) or adjust speech movement patterns to help produce a perceptibly more intelligible speech outcome (Yorkston 1988; Yorkston 1999), and programs aiming to increase vocal intensity such as the Lee Silverman Voice Treatment (Ramig 1995). Traditional speech therapy based in the community remains largely subjective and non-quantitative, i.e. a clinician will train a child to improve their speech sounds as rated using auditory-based, or perceptual outcomes of speech (Dagenais 1995; Secord 1989). The perceptually-based systems such as those listed above have merit in that they are based on representing the actual speech output, which is what the listener attends to (Wood 1999). However, there are many problems with over-reliance on subjective perceptual approaches for measuring and treating disordered speech. One example of issues with perceptual approaches is the use of diagnosis using traditional phonetic transcription systems highlighted by Wood and Hardcastle (Wood 1999). There is a tendency for clinicians to favour 'categorical' errors (e.g. sound substitutions like saying 'pin' when the person meant to say 'bin'), over 'non-categorical' errors (e.g. when sounds are actually distorted so /d/ may be produced in a prolonged and imprecise manner) (Ziegler 1989). Children with dysarthria most commonly experience sound distortions, the errors that are most often poorly transcribed by clinicians, demonstrating the unreliability of traditional auditory-based techniques for treating this population. If a clinician trained in listening to speech is unable to detect subtle differences such as those heard in dysarthria, then the use of such perceptually based techniques bodes poorly for the client who

would also inevitably not be able to correctly hear and define and rectify their own disorder based on auditory feedback alone. As afore-mentioned however, despite the lack of objectivity, perceptual evaluation retains optimal face validity, and is the primary assessment tool used by speech-language pathologists. Moreover, current instrumental assessment options lack the applicability and ease of use offered by perceptual judgements.

There have been attempts to make the treatment, and the outcome measures for rating adult treatment for dysarthria, objective and quantifiable by using instrumental techniques such as electropalatography (EPG) (Hardcastle 1985), or the VisiPitch© (Kay Elemetrics) or Speech Viewer © (Bougle 1995). EPG for example, requires the participant to wear a custom-made acrylic mould of the individual's hard palate that is embedded with 62 sensor electrodes. The electrodes record tongue contact with the palate during speech. This technique is unique because it provides a dynamic visual presentation of lingual movements that could not previously be seen by clinicians or individuals with speech impairment (Hardcastle 1991; Hardcastle 1985). The additional visual feedback provided by EPG during speech therapy may be particularly beneficial in treating patient's following brain injury because these patients often have difficulties with understanding verbal or auditory instructions, which are traditionally used by clinicians in remediation programs (Chapman 2001; Yorkston 1997). Visual biofeedback techniques provide a more tangible or concrete example of the patient's speech pattern for remediation avoiding the need for complex instructions. Whilst both the traditional perceptually-based and instrumentally based biofeedback techniques have been advocated for the remediation of speech disorders due to brain damage in adults, there have been few investigations of treatment efficacy for children with speech disorders due to brain injury, and we cannot assume that the same principles and practices can be successfully applied to the paediatric population. It is also not known how age, severity of brain injury, site of brain lesion not severity of dysarthria impact upon treatment success.

Why it is important to do this review

Dysarthria is a common and often persistent sequelae of traumatic brain injury that may impact upon an individual's quality of life, and in their ability to participate in society. To date there has been no investigation of the effectiveness of perceptual and instrumental treatments for dysarthria in the paediatric population with acquired brain injury. Given the variety of developmental stressors such as neurological maturation, and maturation of the subsystems of speech production (e.g. lips, tongue, etc), we cannot extrapolate the findings of adult investigations in this area to the paediatric population. Therefore, it is the aim of the current paper to systematically review evidence on the efficacy treatment for dysarthria in the paediatric population with acquired brain in-

jury through the evaluation of quasi-randomised and randomised controlled trials.

OBJECTIVES

To assess the efficacy of intervention delivered by Speech and Language Pathologists/Therapists targeting dysarthric speech in children resulting from acquired brain injury.

METHODS

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCT) studies and quasi-randomised design studies (e.g., studies in which participants were allocated on alternate days) were considered for inclusion in this review.

Types of participants

Children aged 3-16 years with acquired dysarthria. Participants were intended to be grouped together by aetiology, (e.g., posterior fossa tumour, other tumours/gliomas, TBI post-fall, TBI post-RTA etc) and paediatric populations with co-morbid conditions such as cognitive or language impairment were to be included in the review.

Types of interventions

1) Perceptually-based therapy: Intervention using traditional drill exercises without instrumentation in the absence of feedback other than auditory feedback, and typically in the absence of using any instrumentation e.g., exercises of the lips or tongue to increase the rate, strength, range or co-ordination of the musculature supporting articulation; drill breathing exercises to increase respiratory/ breath support for speech; voicing drills to increase the loudness of phonation, etc.

2) Instrumentally-based biofeedback approaches: Interventions that use some form of instrumentation and that provide visual or other forms of biofeedback in addition to auditory feedback (e.g., electropalatography; kinematics; visual biofeedback acoustic treatment).

Control groups could include no treatment or wait-list control.

Types of outcome measures

Primary outcomes

Three levels of outcomes were considered for analysis used to measure change (Law 2003) in articulation, phonation, resonance, prosody and respiration or a combination of any of these areas typically affected by dysarthria:

1. At the isolated function level of speech production, e.g. a reduction in single phoneme or sound production duration during articulation.
2. At the single word or sentence level of general speech production, e.g. improvement in rate of single word reading.
3. At the broader level of speech production where outcomes demonstrate functional gains in communication, e.g. improvement in timing of spontaneous speech; reported improvement in speech rate via child or parent report of speech function.

Both standardised and informal outcome measures were considered for evaluation, including clinician, parent or child questionnaire reports on outcome. Outcome measures for all features of dysarthria (i.e. nasality; articulation; laryngeal function; respiratory function) were be considered

Search methods for identification of studies

Electronic searches

The following databases were searched:

Cochrane Central Register of Controlled Trials (CENTRAL), published in The Cochrane Library searched Issue 4, 2006

MEDLINE searched 1966 to January 2007

CINAHL searched 1982 to December 2006

EMBASE searched 1980 to January 2007

ERIC searched 1966 to January 2007

Linguistics Abstracts Online searched 1985 to January 2007

PsycINFO searched 1872 to January 2007

The search strategies used for search the databases can be found in: [Appendix 2](#); [Appendix 3](#); [Appendix 4](#); [Appendix 5](#); [Appendix 6](#); [Appendix 7](#); [Appendix 8](#).

Searching other resources

We requested information on unpublished trials from authors of published studies, and experts and information groups in the areas of linguistics and speech therapy.

Data collection and analysis

Selection of studies

Titles and abstracts were independently screened for inclusion by both authors (AV) and (AM). In cases of uncertainty over whether an abstract met the inclusion criterion by either author, the full text article was obtained. Each paper was then evaluated independently by the two reviewers (AV) and (AM) for inclusion. In the event of disagreement over inclusion of a particular paper, a consensus was formed by AV and AM re-assessing the inclusion criterion together.

Data extraction and management

No studies met inclusion criteria for this review. For details of methods from the protocol which have been archived for use in future updates of this review, see [Appendix 1](#).

Assessment of risk of bias in included studies

See [Appendix 1](#).

Measures of treatment effect

See [Appendix 1](#).

Dealing with missing data

See [Appendix 1](#).

Assessment of heterogeneity

See [Appendix 1](#).

Assessment of reporting biases

See [Appendix 1](#).

Data synthesis

See [Appendix 1](#).

Subgroup analysis and investigation of heterogeneity

See [Appendix 1](#).

Sensitivity analysis

See [Appendix 1](#).

RESULTS

Description of studies

Results of the search

Of the 2091 titles and abstracts identified via the computer-generated search strategy, only three studies appeared to meet the inclusion criterion ([Morgan 2007](#); [Murdoch 1999](#); [Netsell 2001](#)) and the full text versions of the papers were obtained. The remaining 2088 were excluded, largely on the basis of not including dysarthria; being diagnostic or descriptive (i.e., not treatment studies); and for being adult and not child-based. The three full text articles were examined by AM and AV, and the [Netsell 2001](#) paper was excluded as it was a treatment review paper and not an intervention study. The [Morgan 2007](#) and [Murdoch 1999](#) paper were excluded as the study designs were not RCT or quasi-experimental. A further six citations were identified from the Murdoch 1999 paper and obtained. AM and AV then evaluated the titles and abstracts of these additional citations and determined that none of the papers met criterion for inclusion, i.e. the population was not appropriate ([Gallegos 1992](#)); the study examined adults with dysarthria and not children ([Simpson 1988](#); [Thompson-Ward 1997](#)), or the study was not an RCT/quasi-randomised study ([Horton 1997](#); [Workinger 1992](#)). Therefore no study met the eligibility criteria for inclusion in the review. Inter-rater reliability for inclusion was 100% between AM and AV.

Risk of bias in included studies

Not applicable.

Effects of interventions

There are currently no quasi-randomised or randomised studies in this field. Therefore no study met the eligibility criteria for inclusion in the review.

DISCUSSION

The objective of the present review was to investigate the effectiveness of speech intervention for children aged three to sixteen years old with dysarthria following acquired brain injury. No study met the eligibility criteria for inclusion in the present review, i.e. there are currently no quasi-experimental or RCT studies in this field.

In the absence of quasi-experimental or RCT studies in this field, one example of best evidence to date is the Murdoch 1999 paper

(Murdoch 1999). This single-case ABAB study compared traditional (B1) and instrumental biofeedback (B2) therapy techniques. Respiration or speech breathing treatment was evaluated in a 12.5 year old child who had sustained left parietal lobe damage due to a motor vehicle accident, two and half years prior to the study commencement. The participant had a chronic mixed spastic-ataxic-flaccid dysarthria with severely impaired respiratory function being the predominant features. The main goals of the therapy were to: i) increase the participant's control of inhalation and exhalation, and ii) improve the participant's co-ordination of phonation and exhalation. Following treatment, the authors suggested that the real-time continuous biofeedback treatment was not only effective, but superior to traditional therapy in the modification of speech breathing patterns for their case with persistent dysarthria following severe TBI. They conclude that a physiological biofeedback treatment approach is potentially useful for the remediation of speech breathing impairment in children with dysarthria.

This single case study was well designed overall with the child acting as their own control against a comparison of two treatment methods. Methodological strengths of the study include adequate reporting of the baseline assessment characteristics, and the reporting of missing or unanalysable data. Furthermore, the treatment methods were outlined in extensive detail and would enable replication of most components of the study. More prescriptive detail could have been provided about the steps in the progression along the speech and non-speech hierarchy however, and the specific number of items administered within each level of the hierarchy. The participant was assessed with a comprehensive battery of both physiological and perceptual tools at multiple time-points. Whilst it is useful to investigate the impact of treating a specific deficit on other areas of performance, the large number of varied assessments performed frequently weakened the statistical power of this case study. Perhaps a more beneficial statistical method of evaluating treatment efficacy with multiple baseline assessments on a single case would be to perform ANOVAs on a small number of well defined speech outcomes. This method was used successfully by Hartelius 2005 to investigate the efficacy of EPG treatment in a single adult case with dysarthria.

Interestingly, outcome measures used in this study (Murdoch 1999) were based at the impairment level of speech production, and were conducted by the clinician in a clinical setting only. There were no outcome measures of activity or handicap, or other functional everyday measures of communication, no evaluation of speech function in varying communicative contexts more naturalistic to the child (i.e. school, home), and no measures rated by the child or the child's parent/caregiver. There has been an increasing drive to address functional speech outcomes beyond the level of impairment for over a decade (Yorkston 1996). Both the fields of paediatric developmental (Hustad 2002, Hustad 2003) or adult acquired dysarthria (Yorkston 1996, Yorkston 1999) have focused on addressing variables external to the person with dysarthria, in-

cluding listener variables of comprehension of the speech signal, in addition to other environmental factors (e.g., noise level and barriers to participant in various contexts). Future systematic treatment efficacy studies should address functional issues external to the speaker (i.e. impact of treatment on the listener's ability to comprehend the individual) and impairment level (e.g., ratings of participation and activity) (WHO 2002). As aforementioned however, it is important to balance rating multiple outcomes with appropriate statistical power.

An obvious reason for the lack of studies, particularly RCTs, in this particular field is likely related to the heterogeneous nature of both the ABI and the resultant dysarthria in this group. Clearly there are misgivings related to a single subject design, including poor generalisability of study findings to the wider population with dysarthria post-ABI. However the heterogeneous nature of ABI means that researchers will need to think laterally in terms of RCT design and will likely need to collaborate across centres at a national or international level in order to match groups of homogeneous participants. Conducting even a multi-centre RCT with participants matched on relevant variables such as neural lesion site however, may still be ambitious given that lesions within a similar brain region may still cause differential behavioural outcomes (e.g., damage to the cortical region of the inferior frontal gyrus, or posterior Broca's area, may in some cases be contained to this region, and in other cases damage to the white matter may also occur and disrupt connectivity between further regions in the brain).

Another possible reason to explain the critical lack of treatment studies in this area is the absence of a paediatric-based classification system for dysarthria associated with ABI. There is currently no comprehensive child-focused diagnostic system for rating dysarthria (e.g., no child-based equivalent of the MAYO clinic or Darley 1969ab dysarthria classification system). The lack of a diagnostic system may in turn be due to a lack of data on the natural history of speech outcome following ABI in children. The majority of paediatric studies have focused on dysarthria following cerebellar tumour, and rather than focusing on all forms of dysarthria post-ABI in this group, researchers have been more heavily focused on the select group of children with mutism and subsequent dysarthria following surgical removal of cerebellar tumour (see De Smet 2007 for review). There have been even fewer studies of speech outcome or recovery in other ABI groups, with only a handful of studies investigating the natural history or features of children with TBI (Cahill 2002; Cahill 2004), and no thorough descriptions of speech function following CVA.

Not only have the speech outcomes of these populations been poorly described, but even fewer studies have made attempts to systematically and prospectively examine the neural outcome related to speech outcome, despite the very cause of acquired dysarthria being due to neural damage in this population. An exception to this weakness in the field is the work of Richter 2005 and Ozimek

2004 in children with cerebellar tumour. These groups combine neuroimaging and speech data to aid understanding of the underlying basis of speech behaviour. A failure to address the neural basis of speech outcome is a further likely reason for the lack of a development of at least an equivalent neurobehavioural speech classification system to the adult-based MAYO clinic model. Without an appropriate model with which to identify areas of speech impairment, it is difficult to determine appropriate treatment targets, and subsequently it is challenging to develop suitable treatment approaches, let alone measure their effectiveness

A further challenge in determining efficacious interventions is our lack of understanding of the propensity for recovery or rehabilitation of speech function in these patients. We have very little understanding of the characteristics/natural history/recovery patterns of this paediatric population. At the present time we are unable to predict which patients will recover versus those that will have chronic persistent communication impairment. Nor do we understand the time factors involved in recovery or improvement of speech function. As a result, we do not understand the extent to which we can effect change, or rehabilitate speech production. In addition, we have little understanding of the optimal time frame for intervention for these patients. Longitudinal natural history or observational studies are required to provide data on factors predicting the presence and recovery versus persistence of dysarthria associated with ABI. This information will enable a crucial first step in treatment planning, i.e. to determine whether sub-groups of patients should receive rehabilitative versus compensatory versus alternative communication approaches.

A final factor impacting upon the lack of treatment evidence in this particular field (paediatric dysarthria) relates more broadly to the profession of SLP/SLT. Like many other professions allied to medicine, a true push for evidence-based practice in SLP/SLT has really only occurred over the last decade. The recent nature of this drive is evidenced by the term 'evidence-based practice' only appearing in association with SLP/SLT in papers from 2001 only (when using search engines relevant to allied-health professions, i.e., PubMed, CINAHL, Web of Science, Medline, Academic Search Premier).

This awakening of the need for evidence-based practice within the profession has brought with it an increased focus on teaching research methodologies, and on encouraging clinical-research within academic institutions training SLPs/SLTs. Similarly within health-based services in particular, there has been an increasing focus on the development of policies and protocols, underpinned by evidence, to guide clinical practice. As a rule this research focus and culture is more advanced in adult health care settings, and is only in the early stages of development within the paediatric health care setting. One advancement in child-focused research culture is that major paediatric tertiary hospitals (settings where children with dysarthria are commonly seen, at least in the acute stages of care) now commonly have established research governance poli-

cies and supports. Community, education or private-sector paediatric settings however are typically further behind in establishing a research culture. The presence of a limited research culture across many clinical settings highlights a significant problem given that the department in which an SLP/SLT works has been demonstrated to impact upon their use of research (Pennington 2005). A number of authors have reported on the barriers and issues to be considered in implementing research and EBP in the SLP/SLT profession (Kent 2006; Ratner 2006; Reilly 2004; Zipoli 2005). The impacts of these broader research training and support issues on the lack of evidence in this field must be considered.

AUTHORS' CONCLUSIONS

Implications for practice

The present review is unable to draw any conclusions on the efficacy of treatment methods for children aged three to sixteen years with dysarthria associated with ABI, as there are currently no RCTs or quasi-experimental studies in this field. The example of best evidence in this field was a case study (Murdoch 1999) that descriptively reported an improvement in speech function following traditional and biofeedback treatment for speech breathing. Further research is desperately needed in this field however, before any treatment methods can be definitively advocated for use in clinical practice.

Clinicians managing individuals with paediatric dysarthria should be empowered to engage in research through establishing links with local research-focused centres (e.g., academic institutions).

Implications for research

Performing large scale 'natural history' studies, or studies that track dysarthric speech outcome from the acute care setting through to outpatient rehabilitation and in the longer-term are a necessary step to help us understand this group. Specific areas for further investigation include: predictive factors associated with ABI that result in dysarthria, factors predicting the persistence versus recovery of dysarthria, the relationship between underlying neural lesion and speech outcome, the relationship between age at onset of injury and outcome, and the relationship between co-morbid impairments (e.g., motor, cognition, language) and speech outcome. The provision of this data may also help in determining a paediatric-based diagnostic system for dysarthria associated with ABI.

There is a critical need for further studies of treatment efficacy for dysarthria in children post-ABI. Careful thought should be applied to the design of treatments for this challenging patient group. RCTs will be difficult to design given the heterogeneity of not only the nature and type of ABI, but also in relation to the likely complex dysarthria outcome. Natural history studies will

inform the eligibility criterion for sub-groupings for RCTs in the future.

Future studies may investigate numerous treatment and treatment outcome variables common across many speech and language populations (Law 2003) to increase our understanding of treatment response in this population, including:

- outcome measures of interest (e.g., across one or more areas of impairment participation and activity)
- type of treatment and level of breakdown treated (e.g., traditional versus biofeedback, rehabilitative versus compensatory versus alternative communicative interventions, treatment at the impairment versus activity versus handicap level, treating speaker variables or listener variables, etc)
- duration and intensity of treatment (e.g., intervention once/week over a year or 10 sessions over two weeks)
- response of particular sub-groups of participants to treatment (e.g., sub-groups based on age, specific site of brain lesion, or dependent upon similarity of co-morbid non-linguistic factors (e.g., gross and fine motor or cognitive outcome)
- impact of timing of treatment (e.g., intervention during the first three months in the acute period versus in the longer-term

at one year post-injury)

- the effect of the administrator of treatment (e.g., clinician, parent or participant administered therapy)
- the environment in which treatment is administered (e.g., clinical setting, school, community)
- generalisation factors (e.g., impact of treating one component of the speech system on other facets of speech production; or the generalisation of treating speech in the school setting to the community setting, etc)
- the impact of dysarthria severity on treatment outcome
- the impact of non-linguistic co-morbid features (e.g., cognition, motor) on treatment outcome

ACKNOWLEDGEMENTS

We are grateful to Jane Dennis of the University of Bristol, Professor Geraldine Macdonald of Queen's University, Belfast (UK), and Professor James Law of Queen Margaret University College, Scotland, for their support and guidance throughout the review development process.

REFERENCES

References to studies excluded from this review

Gallegos 1992 *{published data only}*

Gallegos K, Medina R, Espinoza E. Electromyographic feedback in the treatment of bilateral facial paralysis: a case study. *Journal of Behavioral Medicine* 1992;**15**:533–9.

Horton 1997 *{published data only}*

Horton SK, Murdoch BE, Theodoros DG, Thompson EC. Motor speech impairment in a case of childhood basilar artery stroke: treatment directions derived from physiological and perceptual assessment. *Pediatric Rehabilitation* 1997;**1**:163–77.

Morgan 2007 *{published data only}*

Morgan AT, Ligeois F, Occomore L. Electropalatography treatment for articulation impairment in children with dysarthria post-traumatic brain injury. *Brain Injury* 2007;**21**(11):1183–93.

Murdoch 1999 *{published data only}*

Murdoch BE, Pitt G, Theodoros DG, Ward E. Real-time continuous visual biofeedback in the treatment of speech breathing disorders following childhood traumatic brain injury: report of one case. *Pediatric Rehabilitation* 1999;**3**: 5–20.

Netsell 2001 *{published data only}*

Netsell R. Speech aeromechanics and the dysarthrias: Implications for children with traumatic brain injury. *Journal of Head Trauma Rehabilitation* 2001;**16**(5):421–5.

Simpson 1988 *{published data only}*

Simpson MB, Till JA, Goff AM. Long term treatment of severe dysarthria: a case study. *Journal of Speech and Hearing Disorders* 1988;**53**:433–40.

Thompson-Ward 1997 *{published data only}*

Thompson-Ward EC, Murdoch BE, Stokes PD. Biofeedback rehabilitation of speech breathing for an individual with dysarthria: a case study. *Journal of Medical Speech/Language Pathology* 1997;**5**:277–88.

Workinger 1992 *{published data only}*

Workinger M, Netsell R. Restoration of intelligible speech 13 years post-head injury. *Brain Injury* 1992;**6**:183–7.

Additional references

Bellaire 1986

Bellaire K, Yorkston KM, Beukelman DR. Modification of breath patterning to increase naturalness of a mildly dysarthric speaker. *Journal of Communication Disorders* 1986;**19**:271–280.

Beukelman 1978

Beukelman DR, Yorskton KM. Communication options for patients with brainstem lesions. *Archives of Physical Medicine and Rehabilitation* 1978;**59**:337–340.

Bougle 1995

Bougle F, Ryalls J, Le Dorze G. Improving fundamental frequency modulation in head trauma patients: A preliminary comparison of speech-language therapy conducted with and without IBM's Speech Viewer. *Folia Phoniatrica Logopaedia* 1995;**47**:24–32.

Cahill 2002

Cahill L, Murdoch B, Theodoros D. Perceptual analysis of speech following traumatic brain injury in childhood. *Brain Injury* 2002;**16**(5):415–46.

Cahill 2004

Cahill LM, Turner AB, Stabler PA, Addis PE, Theodoros DG, Murdoch BE. An evaluation of continuous positive airway pressure (CPAP) therapy in the treatment of hypernasality following traumatic brain injury. A report of 3 cases. *Journal of Head Trauma Rehabilitation* 2004;**19**(3): 241–53.

Cahill 2005

Cahill LM, Murdoch BE, Theodoros DG. Articulatory function following traumatic brain injury in childhood: a perceptual and instrumental analysis. *Brain Injury* 2005;**19** (1):41–58.

Chapman 2001

Chapman SB, McKinnon L, Levin HS, Song J, Meier MC, Chiu S. Longitudinal outcome of verbal discourse in children with traumatic brain injury: three-year follow-up. *Journal of Head Trauma Rehabilitation* 2001;**16**(5): 441–455.

Cornwell 2003a

Cornwell PL, Murdoch BE, Ward EC, Morgan AT. Dysarthria and dysphagia following treatment for a fourth ventricle choroid plexus papilloma. *Journal of Clinical Neuroscience* 2003;**10**(4):506–512.

Cornwell 2003b

Cornwell PL, Murdoch BE, Ward EC, Morgan AT. Dysarthria and dysphagia as long-term sequelae in a child treated for posterior fossa tumour. *Pediatric Rehabilitation* 2003;**6**(2):67–75.

Crow 1989

Crow E, Enderby P. The effects of an alphabet chart on the speaking rate and intelligibility of speakers with dysarthria. In: K.M. Yorkston, D.R. Beukelman editor(s). *Recent Advances in Clinical Dysarthria*. Boston: College-Hill Press, 1989:99–107.

Dagenais 1995

Dagenais PA. Electropalatography in the treatment of articulation/phonological disorders. *Journal of Communication Disorders* 1995;**28**:303–29.

De Smet 2007

De Smet HJ, Baillieux H, Catsman-Berrevoots C, De Deyn PP, Marien P, Paquier PF. Postoperative motor speech production in children with the syndrome of cerebellar

mutism and subsequent dysarthria: A critical review of the literature. *European Journal of Paediatric Neurology* 2007; **11**:193–207.

DeBodt 2002

DeBodt MS, Hernandez-Diaz Hiuci ME, Van De Heyning PH. Intelligibility as a linear combination of dimensions in dysarthric speech. *Journal of Communication Disorders* 2002;**35**:283–292.

Hardcastle 1985

Hardcastle WJ, MorganBarry RA, Clark CJ. Articulatory and voicing characteristics of adult dysarthric and verbal dyspraxic speakers: An instrumental study. *British Journal of Disorders of Communication* 1985;**20**:249–270.

Hardcastle 1991

Hardcastle WJ, Gibbon FE, Jones W. Visual display of tongue-palate contact: Electropalatography in the assessment and remediation of speech disorders. *British Journal of Disorders of Communication* 1991;**26**:41–74.

Hartelius 2005

Hartelius L, McAuliffe MJ, Murdoch BE, Theodoros DG. The use of electropalatography in the treatment of disordered articulation in traumatic brain injury: a case study. Speech Motor Control in Normal and Disordered Speech. 4th International Speech Motor Conference. Nijmegen, The Netherlands: Uitgeverij Vantilt, 2001: 192–5.

Hawley 2003

Hawley CA, Ward AB, Long J, Owen DQ, Magnay AR. Prevalence of traumatic brain injury amongst children admitted to hospital in one health district: A population-based study. *Injury:International Journal of the Care of the Injured* 2003;**34**:256–260.

Helm 1979

Helm NA. Management of palilalia with a pacing board. *Journal of Speech and Hearing Disorders* 1979;**44**:350–353.

Higgins 2002

Higgins JPT, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine* 2002;**21**:1539–1558.

Higgins 2008

Higgins JPT, Green S (eds). *Cochrane Handbook for Systematic Reviews of Interventions 5.0 [updated February 2008]*. Available from www.cochrane-handbook.org: The Cochrane Collaboration, 2008.

Hustad 2002

Hustad KC, Beukelman DR. Listener comprehension of severely dysarthria speech: effects of linguistic cues and stimulus cohesion. *Journal of Speech, Language and Hearing Research* 2002;**45**:545–58.

Hustad 2003

Hustad KC, Jones R, Dailey S. Implementing speech supplementation strategies: Effects on intelligibility and speech rate of individuals with chronic severe dysarthria. *Journal of Speech, Language and Hearing Research* 2003;**46**: 464–74.

Kay Elemetrics

Kay Elemetrics Corporation. Visi-Pitch. *Visi-pitch*. Lincoln Park, NJ: Kay Elemetrics Corp, nd.

Kent 2006

Kent RD. Evidence-based practice in communication disorders: progress not perfection. *Language Speech and Hearing Services in Schools* 2006;**37**(4):268–70.

Law 2003

Law J, Garrett Z, Nye C. Speech and language therapy interventions for children with primary speech and language delay or disorder. *Cochrane Database of Systematic Reviews* 2003, Issue 4. DOI: 10.1002/14651858.CD004110

Michaud 1993

Michaud LJ, Duhaime AC, Batshaw ML. Traumatic brain injury in children. *Pediatric Clinics of North America* 1993;**40**(3):553–65.

Ozimek 2004

Ozimek A, Richter S, Hein-Kropp C, Schoch B, Gorissen B, Kaiser O, Gizewski E, Ziegler W, Timmann D. Cerebellar mutism- report of four cases. *Journal of Neurology* 2004;**251**:963–72.

Parslow 2005

Parslow RC, Morris KP, Tasker RC, Forsyth RJ, Hawley CA. Epidemiology of traumatic brain injury in children receiving intensive care in the UK. *Archives of Disability in Childhood* 2005;**90**(11):1182–1187.

Pennington 2005

Pennington L, Roddam H, Burton C, Russell I, Russell D. Promoting research use in speech and language therapy: a cluster randomized controlled trial to compare the clinical effectiveness and costs of two training strategies. *Clinical Rehabilitation* 2005;**19**(4):387–97.

Qvarnstrom 1994

Qvarnstrom MJ, Jaroma SM, Laine MT. Changes in the peripheral speech mechanism of children from the age of 7 to 10 years. *Folia Phoniatr Logop* 1994;**46**:193–202.

Ramig 1995

Ramig LE, Pawlas AA, Countryman S. *The Lee Silverman Voice Treatment*. Iowa City: National Center for Voice and Speech., 1995.

Ratner 2006

Ratner NB. Evidence-based practice: an examination of its ramifications for the practice of speech-language pathology. *Language Speech and Hearing Services in Schools* 2006;**37**(4): 257–67.

Reilly 2004

Reilly S. The challenges in making speech pathology practice evidence based. *International Journal of Speech-Language Pathology* 2004;**6**(2):113–24.

Richter 2005

Richter S, Schoch B, Ozimek A, Gorissen B, Hein-Kropp C, Kaiser O, et al. Incidence of dysarthria in children with cerebellar tumors: a prospective study. *Brain and Language* 2005;**92**:153–67.

Rosenbek 1991

Rosenbek JC, LaPointe LL. The dysarthrias: Description, diagnosis, and treatment. In: D Johns editor(s). *Clinical Management of Neurogenic Communication Disorders*. Little, Brown & Co, 1991:97–152.

Secord 1989

Secord WA. The traditional approach to treatment. In: N.A. Craghead, P.W. Newman, & W.A. Secord editor(s). *Assessment and remediation of articulation and phonological disorders*. 2nd Edition. New York: Macmillan Publishing Co, 1989.

Tennant 1995

Tennant A, Macdermott N, Neary D. The long-term outcome of head injury: implications for service planning. *Brain Injury* 1995;**9**(6):595–605.

Van Mourik 1997

Van Mourik M, Catsman-Berrevoets CE, Paquier PF, Yousef-Bak E, van Dongen HR. Acquired childhood dysarthria: Review of its clinical presentation. *Pediatric Neurology* 1997;**17**(4):299–307.

WHO 2002

World Health Organisation (WHO). *Towards a Common Language for Functioning, Disability and Health ICF 2002*. Geneva: WHO, 2002.

Wood 1999

Wood S, Hardcastle WJ. Instrumentation in the assessment and therapy of motor speech disorders: A survey of techniques and case studies with EPG. In: I. Papatathanasiou editor(s). *Acquired Neurogenic Communication Disorders*. London: Whurr Publishers, 1999:203–248.

Yorkston 1988

Yorkston KM, Beukelman DR, Bell KR. *Clinical Management of Dysarthric Speakers*. Boston: Little, Brown & Co, 1988.

Yorkston 1996

Yorkston JM, Strand EA, Kennedy MRT. Comprehensibility of dysarthric speech: Implications for assessment and treatment planning. *American Journal of Speech-Language Pathology*, 5, 1, 55-66. 1990;**5**(1):55–66.

Yorkston 1997

Yorkston KM, Jaffe KM, Polissar NL, Liao S, Fay GC. Written language production and neuropsychological function in children with traumatic brain injury. *Archives of Physical Medicine and Rehabilitation* 1997;**78**(10): 1096–1102.

Yorkston 1999

Yorkston KM, Beukelman DR, Strand EA, Bell KR. *Management of Motor Speech Disorders in Children and Adults*. Austin, TX: Pro-Ed, 1999.

Ziegler 1989

Ziegler W, Hoole P. A combined acoustic and perceptual analysis of the tense-lax opposition in aphasic vowel production. *Aphasiology* 1989;**3**:449–463.

Zipoli 2005

Zipoli RP, Kennedy M. Evidence-based practice among speech-language pathologists: attitudes, utilization, and barriers. *American Journal of Speech Language Pathology* 2005;**14**(3):208–20.

* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Study	Reason for exclusion
Gallegos 1992	Study examined participant with Moebius Syndrome not ABI
Horton 1997	Not quasi-experimental/RCT (case study)
Morgan 2007	Not quasi-experimental/RCT (case study series)
Murdoch 1999	Not quasi-experimental/RCT (case study)
Netsell 2001	No experimental treatment data included in study
Simpson 1988	Study examined adult participant with dysarthria
Thompson-Ward 1997	Study examined adult participant with dysarthria
Workinger 1992	Not quasi-experimental/RCT (case study)

APPENDICES

Appendix I. Methods for future updates

Data extraction and management

In addition to outcome data, the following information will be documented by both reviewers using a data management form to be developed and piloted: participant details; setting (e.g., community clinic, school, hospital); type of intervention; length and frequency of intervention; professions involved; duration of impairment; level of severity; co-morbidity; assessment tools employed. Any information that is missing or unclear will be requested from the corresponding author. Outcome data will be independently entered on to RevMan by (AV) and (AM) and a re-evaluation of the data and entries performed together by AV and AM to reach consensus on points of disagreement

Assessment of risk of bias in included studies

Included trials will be evaluated against a number of criteria Both reviewers will assess and independently rate the risk of bias of included studies for the aspects: Methodological quality was assessed independently by two review authors (AV and AM) according to the Cochrane Collaboration Handbook (Higgins 2008). Review authors independently assessed the risk of bias within each included study based on the following six domains with ratings of 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias):

1. **Sequence generation** Was the method used to generate the allocation sequence was assessed to determine if it produced comparable groups. Ratings: 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias)

2. **Allocation concealment** Was the method used to conceal allocation sequence described in sufficient detail to assess whether intervention schedules could have been foreseen in advance of, or during, recruitment. In the review authors' judgment was allocation adequately concealed? Ratings: 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias)

3. **Blinding** Were any measures used to blind participants, personnel and outcome assessors described so as to assess knowledge of any group as to which intervention a given participant might have received In the review authors' judgment,; was knowledge of the allocated intervention adequately prevented during the study? Ratings: 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias)

4. **Incomplete outcome data** If studies do not report intention-to-treat analyses, we will make attempts to obtain missing data by contacting the study authors. Data on attrition and exclusions will be extracted and reported as well the numbers involved (compared with total randomised), reasons for attrition/exclusion where reported or obtained from investigators, and any re-inclusions in analyses performed by review authors. In the review authors' judgment: were incomplete data dealt with adequately by the reviewers? (See also 'Dealing with missing data'). Ratings: 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias)

5. **Selective outcome reporting** Attempts will be made to assess the possibility of selective outcome reporting by investigators. In the review authors' judgment: are reports of the study free of suggestion of selective outcome reporting? Ratings: 'Yes' (low risk of bias); 'No' (high risk of bias) and 'Unclear' (uncertain risk of bias)

6. **Other sources of bias** Was the study apparently free of other problems that could put it at a high risk of bias?

Measures of treatment effect

Continuous data: To enable the combination of studies measuring the same outcome using different methods, continuous data will be summarised using standardised mean differences.

Binary data: Binary outcomes are likely to be common in early reports within the field (e.g., improved outcome vs no change/worse). Data will be analysed by calculation of the relative risk with a 95% confidence interval.

Dealing with missing data

Missing data will initially be sought via contact with the corresponding author. In regard to participant drop out, if the rate of attrition reaches a 30% threshold in an included study, the study will be included in the systematic review but not in the meta-analysis. The maximum allowed difference in the dropout rate between the two groups will be 10% before a study included in the review is excluded from meta-analysis.

Assessment of heterogeneity

Consistency of results will be assessed by examining I-squared (Higgins 2002). I-squared is a quantity describing approximately the proportion of variation in point estimates that is due to heterogeneity of a sample rather than error in sampling of the population. A test of homogeneity will be used to determine that the heterogeneity is genuine. In the event of too few studies being available to make this test feasible, a random effects model will be applied

Assessment of reporting biases

Where appropriate, the possibility that the study selection was affected by bias will be assessed using funnel plots to investigate any relationship between effect size and study precision (closely related to sample size). Such a relationship could be due to publication or related biases or due to systematic differences between small and large studies, or a statistical artefact of the chosen effect measure.

Data synthesis

Meta-analysis will be only performed where studies employ similar interventions and where study populations are clinically homogenous.

Appendix 2. MEDLINE search strategy

MEDLINE searched, via OVID, 1966 to January 2007

1 Dysarthria/

2 Speech Disorders/

3 ataxia.tw.

4 (dysarth\$ or dysphon\$ or anarth\$ or dyspros\$ or aphon\$ or dyston\$).tw.

5 ((speech or articulat\$ or voice or vocal or communicat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.

6 ((phonat\$ or prosod\$ or intonat\$ or respirat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.

7 or/1-6

8 Child/

9 Adolescent/

10 (child\$ or girl\$ or boy\$ or pre school\$ or preschool\$ or adolescen\$ or teen\$).tw. (718291)

11 or/8-10

12 (rehabilitat\$ or therap\$ or train\$ or management or assist\$ or measure\$ or assess\$ or remedia\$ or augment\$ or recover\$).tw.

13 technique\$.tw.

14 12 or 13

15 7 and 11 and 14
 16 randomized controlled trial.pt.
 17 controlled clinical trial.pt.
 18 randomized controlled trials.sh.
 19 random allocation.sh.
 20 double blind method.sh.
 21 single-blind method.sh.
 22 or/16-21 (394278)
 23 (animals not human).sh.
 24 22 not 23
 25 clinical trial.pt.
 26 exp Clinical Trials/
 27 (clin\$ adj25 trial\$).ti,ab.
 28 ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj25 (blind\$ or mask\$)).ti,ab.
 29 placebos.sh.
 30 placebo\$.ti,ab.
 31 random\$.ti,ab.
 32 research design.sh.
 33 or/25-32
 34 33 not 23
 35 34 not 24
 36 comparative study.sh.
 37 exp Evaluation Studies/
 38 follow up studies.sh.
 39 prospective studies.sh.
 40 (control\$ or prospectiv\$ or volunteer\$).ti,ab.
 41 or/36-40
 42 41 not 23
 43 42 not (24 or 35)
 44 24 or 35 or 43
 45 44 and 15

Appendix 3. CENTRAL search strategy

CENTRAL searched, via the Cochrane Library, Issue 4, 2006

#1 MeSH descriptor Dysarthria explode all trees
 #2 MeSH descriptor Speech Disorders, this term only
 #3 (ataxia)
 #4 (dysarth* or dysphon\$ or anarth* or dyspros* aphon* or dyston*)
 #5 (speech or articulat* or voice or vocal or communicat*) near/3 (disorder* or impair* or problem* or difficult*)
 #6 (phonat* or prosod* or intonat* or respirat*)near/3 (disorder* or impair* or problem* or difficult*)
 #7 (#1 OR #2 OR #3 OR #4 OR #5 OR #6)
 #8 (child near "MESH check words")
 #9 MeSH descriptor Adolescent explode all trees
 #10 (child* or girl* or boy* or pre school* or preschool* or adolescen* or teen*)
 #11 (#8 OR #9 OR #10)
 #12 (rehabilitat* or therap* or train* or management or assist* or measure* or assess* or remedia* or augment* or recover*)
 #13 technique*
 #14 (#12 OR #13)

#15 (#7 AND #11 AND and#14)

Appendix 4. CINAHL search strategy

CINAHL searched, via OVID, 1982 to December 2006

- 1 Dysarthria/
- 2 Speech Disorders/
- 3 ataxia.tw.
- 4 (dysarth\$ or dysphon\$ or anarth\$ or dyspros\$ or aphon\$ or dyston\$).tw.
- 5 ((speech or articulat\$ or voice or vocal or communicat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.
- 6 ((phonat\$ or prosod\$ or intonat\$ or respirat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.
- 7 or/1-6
- 8 Child/
- 9 Adolescent/
- 10 (child\$ or girl\$ or boy\$ or pre school\$ or preschool\$ or adolescen\$ or teen\$).tw.
- 11 or/8-10
- 12 (rehabilitat\$ or therap\$ or train\$ or management or assist\$ or measure\$ or assess\$ or remedia\$ or augment\$ or recover\$).tw.
- 13 technique\$.tw.
- 14 12 or 13
- 15 7 and 11 and 14
- 16 randomi\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 17 clin\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 18 trial\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 19 (clin\$ adj3 trial\$).mp. [mp=title, subject heading word, abstract, instrumentation]
- 20 singl\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 21 doubl\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 22 tripl\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 23 trebl\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 24 mask\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 25 blind\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 26 (20 or 21 or 22 or 23) and (24 or 25)
- 27 crossover.mp. [mp=title, subject heading word, abstract, instrumentation]
- 28 random\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 29 allocate\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 30 assign\$.mp. [mp=title, subject heading word, abstract, instrumentation]
- 31 (random\$ adj3 (allocate\$ or assign\$)).mp.
- 32 Random Assignment/
- 33 exp Clinical Trials/
- 34 exp Meta Analysis/
- 35 31 or 27 or 26 or 19 or 16 or 32 or 33 or 34
- 36 15 and 35

Appendix 5. EMBASE search strategy

EMBASE searched, via OVID, 1980 to January 2007

- 1 Dysarthria/
- 2 Speech Disorders/
- 3 ataxia.tw.
- 4 (dysarth\$ or dysphon\$ or anarth\$ or dyspros\$ or aphon\$ or dyston\$).tw.
- 5 ((speech or articulat\$ or voice or vocal or communicat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.
- 6 ((phonat\$ or prosod\$ or intonat\$ or respirat\$) adj3 (disorder\$ or impair\$ or problem\$ or difficult\$)).tw.
- 7 or/1-6
- 8 Child/
- 9 Adolescent/
- 10 (child\$ or girl\$ or boy\$ or pre school\$ or preschool\$ or adolescen\$ or teen\$).tw.
- 11 or/8-10
- 12 (rehabilitat\$ or therap\$ or train\$ or management or assist\$ or measure\$ or assess\$ or remedia\$ or augment\$ or recover\$).tw.
- 13 technique\$.tw.
- 14 12 or 13
- 15 7 and 11 and 14
- 16 clin\$.tw.
- 17 trial\$.tw.
- 18 (clin\$ adj3 trial\$).tw.
- 19 singl\$.tw.
- 20 doubl\$.tw.
- 21 trebl\$.tw.
- 22 tripl\$.tw.
- 23 blind\$.tw.
- 24 mask\$.tw.
- 25 ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj3 (blind\$ or mask\$)).tw.
- 26 randomi\$.tw.
- 27 random\$.tw.
- 28 allocat\$.tw.
- 29 assign\$.tw.
- 30 (random\$ adj3 (allocat\$ or assign\$)).tw.
- 31 crossover.tw.
- 32 31 or 30 or 26 or 25 or 18
- 33 exp Randomized Controlled Trial/
- 34 exp Double Blind Procedure/
- 35 exp Crossover Procedure/
- 36 exp Single Blind Procedure/
- 37 exp RANDOMIZATION/
- 38 33 or 34 or 35 or 36 or 37 or 32
- 39 15 and 38

Appendix 6. ERIC search strategy

ERIC searched, via Dialog DataStar, 1966 to January 2007

- 1 ATAXIA.TI,AB.
- 2 (DYSARTH\$ OR DYSPHON\$ OR ANARTH\$ OR DYSPROS\$ OR APHON\$ OR DYSTON\$).TI,AB.
- 3 ((SPEECH OR ARTICULAT\$ OR VOICE OR VOCAL OR COMMUNICAT\$) NEAR (DISORDER\$ OR IMPAIR\$ OR PROBLEM\$ OR DIFFICULT\$)).TI,AB.
- 4 ((PHONAT\$ OR PROSOD\$ OR INTONAT\$ OR RESPIRAT\$) NEAR (DISORDER\$ OR IMPAIR\$ OR PROBLEM\$ OR DIFFICULT\$)).TI,AB.
- 5 (1 OR 2 OR 3 OR 4).TI,AB.
- 6 (CHILD\$ OR GIRL* OR BOY\$ OR PRE ADJ SCHOOL\$ OR ADOLESCEN\$ OR TEEN\$).TI,AB.
- 7 (REHABILITAT\$ OR THERAP\$ OR TRAIN\$ OR MANAGEMENT\$).TI,AB.
- 8 (ASSIST\$ OR MEASURE\$ OR ASSESS\$ OR REMEDIA\$ OR AUGMENT\$ OR RECOVER\$ OR TECHNIQUE\$).TI,AB.
- 9 (7 OR 8).TI,AB.
- 10 5 AND 6 AND 9
- 11 TRIAL\$.TI.
- 12 RANDOMLY.AB.
- 13 PLACEBO.AB.
- 14 (RANDOMIZED OR RANDOMISED).AB.
- 15 TRIAL\$.AB.
- 16 11 OR 12 OR 13 OR 14 OR 15
- 17 10 AND 16

Appendix 7. Linguistics Abstracts Online

LAO searched 1985 to January 2007

Terms used to search LAO:

dysarthria AND child or children

Appendix 8. PsycINFO search strategy

PsycINFO searched, via SilverPlatter, 1872 to January 2007

#18 (((rehabilitat* or therap* or train* or management or assist* or measure* or assess* or remedia* or augment* or recover* or technique*)) and ((child* or girl* or boy* or pre school* or preschool* or adolescen* or teen*)) and ((dysarth* or dysphon* or anarth* or dyspros* or aphon* or dyston*) or (ataxia) or ("Speech-Disorders" in MJ,MN) or ("Dysarthria-" in MJ,MN))) and (("Clinical-Trials" in MJ,MN) or ((randomized or randomised) in AB) or ((trial*) in TI) or (randomly) in AB) or (placebo) in AB)))

WHAT'S NEW

Date	Event	Description
12 May 2008	Amended	Converted to new review format.

CONTRIBUTIONS OF AUTHORS

Angela Morgan had the original idea for the review. Angela Morgan and Adam Vogel contributed to all drafts of the review. They developed the search strategy in concert with Joanne Abbott, TSC of the Cochrane DPLPG.

Both authors contribute to study selection, study assessment, data extraction, data entry, analysis and the final writing of the review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- Murdoch Childrens Research Institute, Australia.

External sources

- No sources of support supplied

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

The methods section has been updated to reflect changes recommended regarding the Cochrane Collaboration's new tool for assessing risk of bias ([Higgins 2008](#)).

INDEX TERMS

Medical Subject Headings (MeSH)

*Speech-Language Pathology; Brain Injuries [*complications]; Dysarthria [etiology; *therapy]; Language Therapy

MeSH check words

Adolescent; Child; Humans